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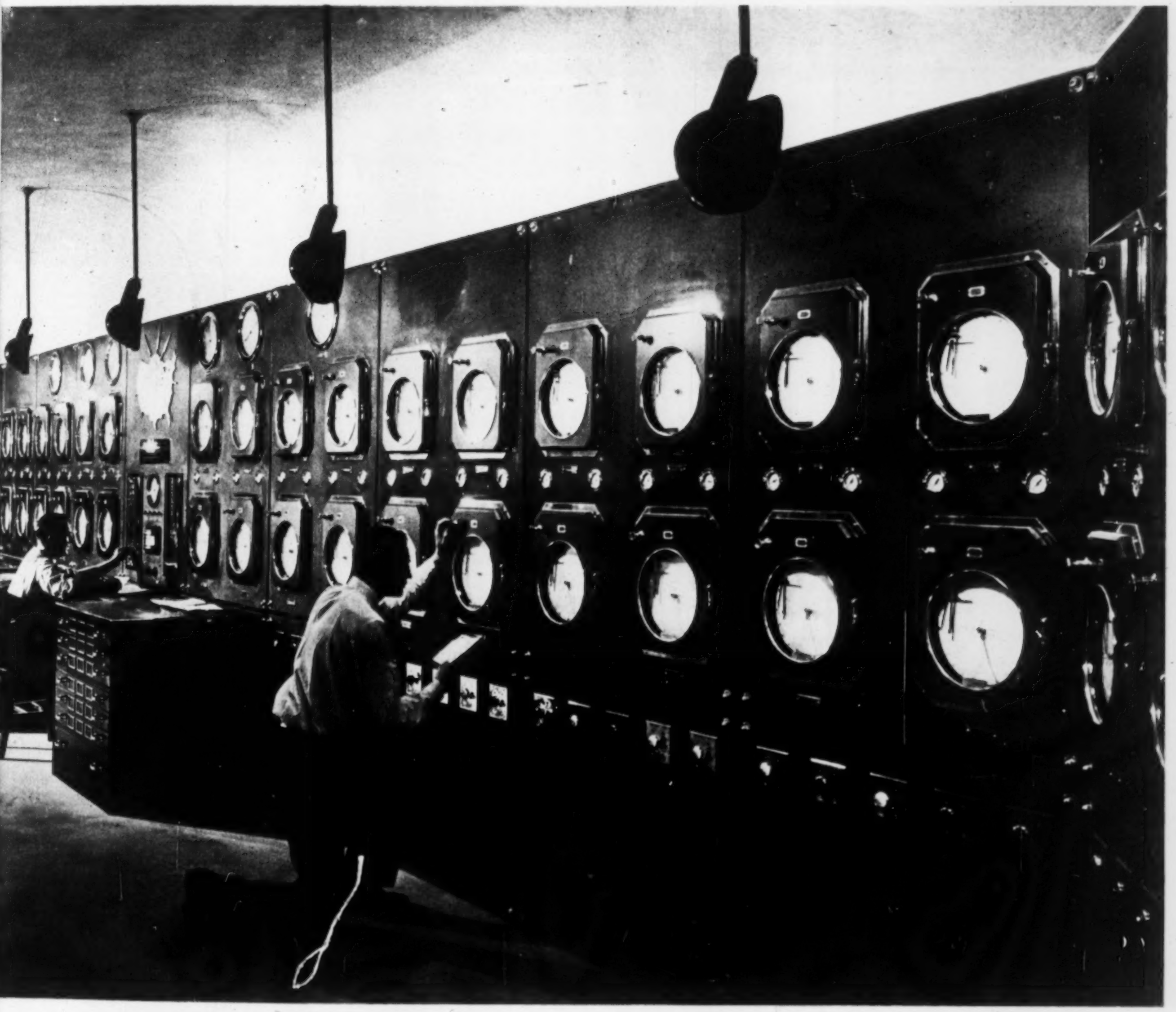
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 7 FEBRUARY, 1934 NUMBER 2



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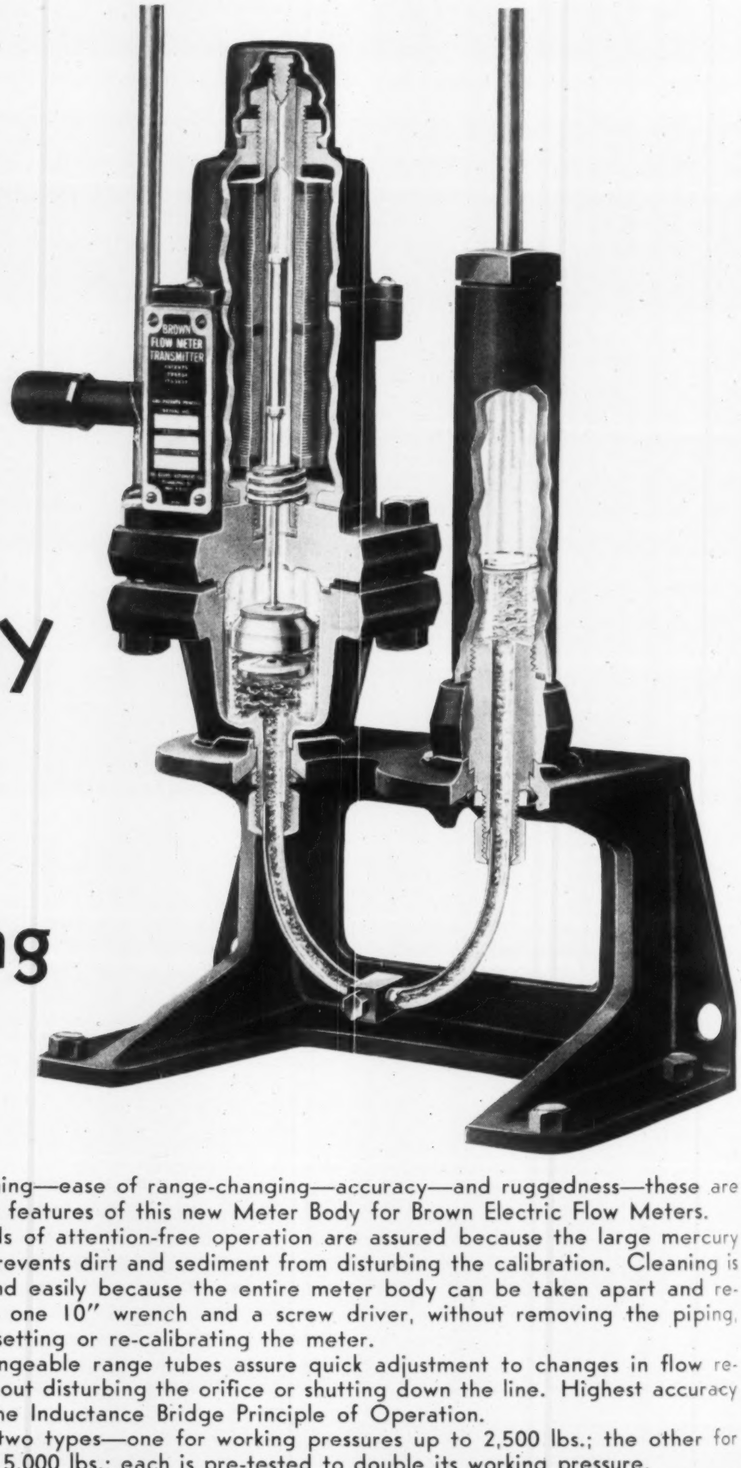

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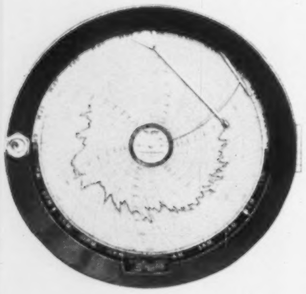

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General Electric Company,
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Please send me information on G-E Recording Instruments.

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INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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Editor

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NEW RECORDING AND REGULATING EFFICIENCY TAYLOR "FULSCOPE" REGULATOR

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NEW RECORDING AND REGULATING EFFICIENCY TAYLOR . "FULSCOPE" REGULATOR .

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1. A graduated dial provides quick, accurate adjustment to the *one best sensitivity* for the controlled apparatus.

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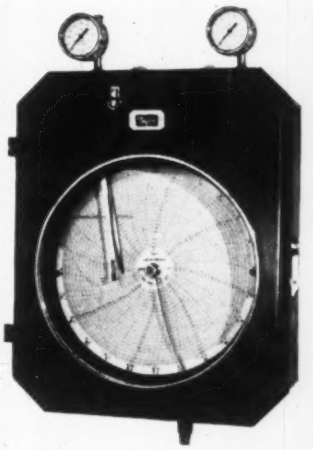
3. Improved setter point adjustment makes possible *more sensitive and more accurate temperature settings.*

4. New type linkage reduces pen drag to the absolute minimum—makes pen drag almost theoretical. *It disappears entirely for intermediate and low points of sensitivity.*



• • NEW FEATURES

5. Improved pen arm gives *more uniform pressure between pen and chart.* Entire arm of flexible stainless spring steel. New type micrometer screw facilitates adjustments.

6. Improved bearings and lighter leverage system without sacrifice of ruggedness practically eliminates friction.

7. Calibration obtained by simply positioning bearing in slot of arm attached to bourdon coil.

8. Tube systems of Taylor Accuratus tubing can be easily replaced on the job with a minimum of adjustments.

A balanced control—new precision and adaptability for every temperature and pressure control requirement

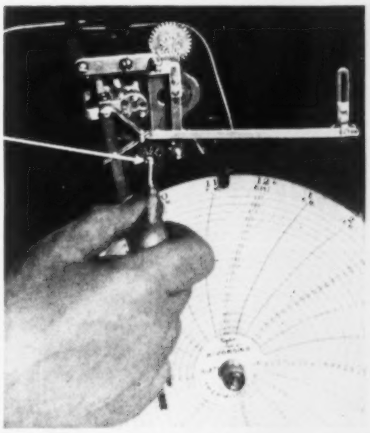
Not just an improved model—the Taylor "Fulscope" Regulator incorporates features which revolutionize regulator application—sets a new standard of accurate control in the regulating and recording of temperatures and pressures.

It provides an adjustment by which the *one correct sensitivity* can be quickly obtained while the instrument is in service. This "Universal Sensitivity Adjuster" can be set, by an unskilled operator, to obtain any character of control desired.

Ease of converting from direct to reverse action—improved setting point adjustment—negligible pen drag—full length flexible pen arm—superior leverage system—ease of calibration—replaceable tube systems—die-cast dust-, moisture-, and fume-proof case. You can appreciate what these advantages mean!

Performance has been proved. In Taylor laboratories—in the field—Taylor "Fulscope" Regulators have been submitted to the most rigid practical tests. Within their range, you are assured of their ability to meet every temperature and pressure control requirement with a degree of accuracy and efficiency never before obtainable.

Send for bulletin giving more details about the Taylor "Fulscope" Regulator or ask a Taylor Representative to call and discuss it with you. Address, Taylor Instrument Companies, Rochester, N. Y.



Just a turn of the screw driver to set this "Universal Sensitivity Adjuster" for the *one best sensitivity* for a particular process. Sensitivity progresses from lowest point, marked "L" on the dial indicated by arrow, to highest point "A" on the dial. Can be quickly made *while the instrument is in operation* to obtain any control desired—steady throttling or on-and-off action.

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Stabilog
POTENTIOMETER
PYROMETER

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100% AUTOMATIC CONTROL UP TO 2800° F.

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RECORDING
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INSTRUMENTS
FOR
PRESSURE
TEMPERATURE
HUMIDITY
LIQUID LEVEL
AND FLOW

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◆ A new era in the control of high temperature has been opene with the introduction of the Foxboro Potentiometer Stabilog. In this instrument, the temperature is measured with the unrestricte accuracy of electrical measurement and controlled with the flexibility known only in air-operated control.

◆ The STABILOG System of Control can be adjusted to mee any condition of lag without "hunting" or over-controlling. The result is a smooth, close control hitherto unattainable in the hig temperature ranges.

◆ Potentiometer Stabilog Control is entirely free from manua auxiliary adjustments—it is **one hundred per cent automatic.** It "stabilizes" the process by correcting conditions so that upsettin surges are not allowed to develop.

◆ Write today for Bulletin 194. It contains detailed informatio on what the Potentiometer Stabilog will do for you.

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EDITORIAL COMMENT

In This Issue

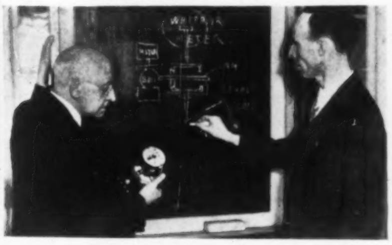
◆ Professor S. R. Williams' years of research into magnetic phenomena and properties at Amherst College, and his Chairmanship since 1918 of the Hardness Testing Committee of the National Research Council, have resulted in many contributions—not the least being his inspiration of younger men. **H. Hunter Smith** proves himself a worthy disciple. It is a privilege for *Instruments* to be selected as a medium of communication by **Professor Kennelly**, and it is not surprising in this instance, for the eminent scientist is an authority on units of weights and measures, and The Magazine of Measurement and Control would seem to be the optimal medium for his concise discussion of the present status of the Metric System. (Note to new readers: *Instruments* is neutral and its columns are open to interesting spokesmen of both sides.)

◆ To control the tension of a fast-traveling paper web is difficult enough; to control it at all speeds—automatically, of course—is one of the toughest problems in engineering, and the solution reported by **H. W. Rogers** contains ideas applicable in other fields of control.

◆ The next article comes from overseas: **G. W. Stubbings** describes a new and convenient modification of the method of determining phase-sequence which he gave in his book on "Commercial A.-C. Measurements."

◆ Before measuring any entity, it is well to know something about its nature. The second instalment of the electrical measurement serial deals mostly with the nature of alternating currents. **Perry Borden** selected those facts which make the best foundation for subsequent discussions of fine points of a.-c. instruments.

◆ Among the many and varied **New Instruments** articles is one describing a demand device of a new type, written by the designer, **B. H. Smith** of the Westinghouse Newark Works. Here we see Ben telling the Grand Old Man of electrical instrument makers, Paul MacGahan, that his device "keeps rolling along as reliably as a watthour meter, which everybody knows is the most reliable constant-motion instrument ever perfected."



The Front Cover

◆ If Radio City is, as some say, "the first wonder of the modern world," it is because it contains so many separate wonders—among them its air-conditioning installation by the Carrier Engineering Corporation and Taylor Instrument Companies. 93 Taylor recorder-controllers provide the "indoor weather" desired.

"You, Too, Can Write"

THERE are two reasons why this advertisement headline is selected as text for a chat on contributing articles to *Instruments*. In the first place, it is true: you (the thousands of *Instruments* subscribers) do write well, as evidenced by your letters in every day's mail, and by technical papers which some of you present before societies.

In the second place, you have something to write about: you may not realize it, but in the course of your work with instruments you probably have achieved a fresh triumph of Instrumentation which technicians in your own field or in others would find stimulating. And *this* assertion is based on the representative cross-section of "you" composed of subscribers we have met.

Some of the most informative *Instruments* articles had to be coaxed out of modest engineers or research workers, who, even when convinced that they had a good story to tell, tried to beg off on the grounds that they lacked the technique of presentation. If that is what deters you, remember that the matter is more important than the manner. Just write it as you would tell it to a colleague. And if you *must* have a formula, here is an extract from a letter to a bashful plant engineer:

> (1) Describe the process; (2) state the elements of the control problem; (3) describe the means adopted; (4) critically evaluate the performance of such means; (5) report the results obtained, and (6) suggest possible future improvements both in the controlled process and in the process control.

But perhaps your specialty is not automatic control but measurement. As to the technique of writing a measurement article (as distinguished from a control article) here are extracts from another recent letter to a "should-be" author:

> Discuss every *method* of measuring the moisture content of various organic and inorganic materials. Give a systematic classification of materials, so that one reader interested in foundry sands, and another who manufactures impregnated textile insulators, will each feel that the article was written for his benefit. Next, a brief systematic classification of the methods—sampling methods and continuous-measurement methods, with the underlying principles of each—illustrated with schematic diagrams.
>
> Then would come the main portion of your article—a critical analysis of each method (not of each instrument on the market) with regard to the following criteria: (a) Attainable sensitivity and accuracy; (b) Range, *i. e.*, whether the method is best for high, low or medium percents of moisture; (c) What kinds of moisture are measured, *i. e.*, free, cellular, etc.; (d) Time required; (e) Possibility or impracticability of automatic measurement and of continuous measurement; (f) Practicability of automatic control based on such method; (g) Suitability for plant or restriction to scientific laboratory; (h) Dependence on auxiliary power, and results of failure or interruption of power supply.
>
> —and any other factors that occur to you, such as whether the instruments employing the particular principle are made portable or not.
>
> Conclude with your personal views on recent progress and future developments.

There are other kinds of articles, among them those about the instrumentation of an entire department, plant, or even industry. Example, "Instruments Help to Build and Sustain a New Industry" (September 1932) in which W. A. Cotton credited Instrumentation with the birth and growth of the Masonite Corporation. If that's the kind of story you have on tap, turn it on by all means!

What's the proper length? Consider what Lincoln said: "My legs aren't too long—they reach exactly from my body to the ground." Some phenomena or results take hundreds of words to describe; others are well told graphically, as in this month's leading article. If you can write a book of interest to your fellow instrument users, we may print it serially; if you have one brief description or comment or narrative which they would profit by, write it up in the form of a Letter to the Editor.

Finally, as to grammar and style: just forget them and write as you would talk. Your editor has only been wielding a blue pencil for a quarter-century but he tries to make up for this inexperience by taking infinite pains with your manuscripts. One thing we seldom can supply is illustrations. Send in lots of them.

M. F. Behar

LETTERS TO THE EDITOR

Calls Attention to an Important Ratio in Free-Float Type Fluid Meters

To the Editor:

In looking over your discussion of area meters of the free-float type in Chapter XXVI of *Flow Measurement and Control* (published in *Instruments*, December 1933) I note that you have given thought to a ratio which apparently had been overlooked in all previous American texts on fluid meters, namely, the relation of the density of the float to the density of the fluid. Your statement

> The density of the float must differ considerably from that of the fluid for two reasons: so that the float will not be carried along, and in order to provide a "load" determining the constant head.

needed to be made, but it seems to me that instead of using the one word "considerably" you would do well to discuss the *optimum ratio* of float density to fluid density. This ratio is very important in the design of these instruments if any variation in the density of the liquid is to be expected. As far as I know, American manufacturers have neglected the influence of the density of the float in this respect.

A theoretical analysis shows that minimum error will be introduced by slight changes in the density of the fluid if the density of the float is *twice* the normal density of the fluid. For example, if an instrument is calibrated for use in measuring aviation gasoline, a variation of 10% in its density will introduce an error in indication of 0.8, 1.5 and 3.2% if the float density is respectively 2, 2.4 and 4 times the fluid density.

Apparently this was first pointed out by P. S. Kerr in British Aeronautic Research Committee Reports and Memoranda No. 1245, 1929. He describes a fuel flow meter of the area type designed to measure mass flow of the engine fuel in airplanes. The theory and a description of the instrument are repeated in Technical Report No. 466 of the U. S. National Advisory Committee for Aeronautics entitled Aircraft Power-Plant Instruments, which publication is probably more easily obtainable.

It should be noted that the instrument developed by Kerr is not strictly of the free float type since a central guide is provided for the float. This is interesting in view of the fact that no description of this type of construction appears in your chapter as published.

Bureau of Standards,
Washington, January 24, 1934
W. G. BROMBACHER

"Large Circulation Around Plant"

To the Editor:

. . . We appreciate your magazine—it has about the largest circulation around the plant of any of those we receive. I am enclosing one of our magazine route list forms that we attach to all magazines after checking off the names of all those who want to see each copy received.

Speer Carbon Company
Saint Marys, Pa.
January 30, 1934
H. W. ABBOTT,
Director of Laboratories

Page Rube Goldberg!

To the Editor:

Mr. M. M. Rose, chief engineer of Electric Generator & Motor Co. in this city, recently solved a difficult motor-generator testing problem in such an ingenious way that readers of *Instruments* interested in test work will, I am sure, get a chuckle out of it. The motor-generator set consisted of a 2200 volt, 25 cycle, two-phase motor coupled to a 230 volt, 100 K.W. direct current generator.

"As our supply current is 60 cycle, 2200 volt, 3 phase, and as we didn't happen to have a suitable 2-phase starter anyway, the usual running test looked like a serious problem," Mr. Rose explained. "It was finally solved as follows: We first transformed our 2200 volt 60 cycle 3-phase current to 440 volts 3-phase 60 cycles. This was converted to 330 volts d.c. by means of a motor-generator. This 330 volt direct current was changed into 220 volts, 3-phase 25 cycles through an 'inverted rotary converter'. Again this was changed by a bank of 'Scott-connected' transformers, into 2 phase, 220 volts, 25 cycles. Finally, it was stepped up through two 220-to-2200 volt single-phase transformers to the required motor voltage.

"The starting was accomplished by using the d.c. end of the machine under test as a motor, bringing it up to as near full speed as possible, and closing the 2200 volt 2-phase circuit on the a.c. side of the set. I'll admit," concluded Mr. Rose, "that the method employed rather suggests one of Rube Goldberg's 'inventions'—only this one *worked.*"

Cleveland, Ohio,
January 20, 1934
V. D. GILES

Page Senator Wheeler!

To the Editor:

Nearly a ton and a half of silver fell on Freeport this afternoon, when the 500 employees and executives of the Burgess industries began spending in the local stores and markets the silver dollars with which they had been paid out of a total silver payroll of $40,000.00 earlier today. At 7:30 a. m., under the watch of guards and police with machine guns, sawed off shotguns, tear bombs and drawn revolvers, the paying off of the 500 employees started. Each was handed a canvas bag weighing about 5 lbs., containing two weeks' pay entirely made up of silver dollars, and this notice:

> Burgess payrolls are being met this one time only in silver dollars. The reasons for this procedure are two: (1) To promote the popularizing of silver currency and to coöperate with the Administration in its silver policies. (2) To demonstrate the importance of our industries to the city of Freeport. Freeport merchants are coöperating in this program; we urge you to spend these silver dollars in the payment of your bills and in the purchase of the unusual values being offered today.

The uses and applications of silver have long constituted a hobby of Dr. C. F. Burgess, Chairman of the Board of the Burgess industries. It is his idea that this distribution of silver dollars is the best way to prove to a community that the silver dollar is a sound, spendable currency. Moreover, the study of the flow of such ear-marked money through channels of trade will show the purchasing power of an industrial payroll in a typical community.

The first silver dollar to be spent belonged to Jeff Dietrich, tinsmith in the Maintenance Dept. He bought a pack of cigarettes from a store on the corner of East Stephenson St. near our plant. The next dollar went to buy gas for Vic Fishburn's car from Mutt Foley's filling station. This reporter was unable to follow the spending of the third, fourth, and fifth and other dollars, for their going was too fast and in too many directions. It was noticed that in the case of Bolva Molter, switchboard operator, at least five of the silver dollars were at once deposited in the silk-stocking bank where they made a not inconsiderable bulge.

By early evening some of the dollars had traveled as far as Dixon, Stockton, Orangeville, Lena, Monroe, Elizabeth, Byron, Oneco, Davis and Polo, as well as other outlying towns and districts.

The $40,000.00 shipment came from the Chicago Federal Reserve Bank, took about a week for the several banks to collect it, and its total weight was almost 2,600 lbs. If the silver in these dollars were spun into a fine wire, it would stretch from our plant at Freeport to the New York office of *Instruments* about 1500 times.

Freeport, Ill.
January 20, 1934
JACKSON BURGESS

Demon Editor's Note: What do you mean, "a fine wire" and "about 1500 times"? An instrument engineer of your standing should stick to quantitative data and avoid qualitative expressions.

"Much Useful Information"

To the Editor:

. . . My subscription to *Instruments* has brought me much useful information. The article in the December 1933 issue, "Automatic Control Instruments Applied to the Zeolite Water Softening Process," by Eric Pick, is but one of many instances. Could you send me a reprint of it?

Dayton, Ohio
January 29, 1934
E. F. STEGER

We can. Reprints of feature articles are run off for their authors, but a few extra copies find their way to *Instruments'* office.

Measuring Mechanical Hardness with Magnetic Instruments

By H. HUNTER SMITH*

WHAT, precisely, *is* hardness? Jeffries and Archer[1] define mechanical hardness as the "resistance to permanent deformation." At the present time the outstanding instruments for measuring hardness are the Brinell, Rockwell and Herbert hardness testers. These are indentation methods, in which the relative hardnesses of various bodies may be compared by the relative distances to which a small steel ball or a diamond point will penetrate the material when a given load is applied to the ball or the diamond point. The penetration of the steel ball or diamond point, into the substance being tested, causes permanent deformations. The softer the material, the greater will be the penetration or permanent deformation.

If one takes into account methods like Mohs' scratch tests, or the measurement of hardness by the height of rebound of a steel ball or by the abrasion method, it is evident that the user of one method does not have in mind exactly the same property of matter as the individual who uses another method.

For lack of a general agreement on the subject, this indefinite conception—of what hardness really is—calls for further study of the methods already employed and for the production of new methods. It is of interest, therefore, to see what may be done in measuring mechanical hardness by magnetic instruments.

Mechanical hardness of steel may be varied in different ways: (1) by heat treatment, (2) by cold working, (3) by varying the carbon content, and (4) by magnetic tempering.

In this study a group of six iron-carbon rods had their hardness varied by a difference in their carbon content. The heat treatment, thus far, has been hot rolling into long cylindrical rods with an average diameter of 0.641 cm. After having been finished hot, they were allowed to cool without interruption on the cooling beds. They all, therefore, have had the same heat treatment. The important point to be kept in mind is that whatever the carbon content, hardness, hysteresis loss or any other physical property was, comparative tests were made on the same, identical rods. Supposedly identical treatment does not always produce identical results. Reliable comparisons of magnetic properties and mechanical hardness can be made only on the same specimens.

While many[2] have studied the magnetic properties of iron-carbon alloys, no one appears to have made a comprehensive study of the relations of permeability, hysteresis loss and coercive force to the property of mechanical hardness.

Through the courtesy of the Carnegie Steel Co. of Pittsburgh, Pa., this group of six steel rods was furnished for the comparative studies mentioned above.

The rods had a common length of 24.5 cm. with practically the same cross-sectional area. See table on next page. The rods carried the following designations: A_6, B_6, C_6, D_6, E_6 and F_6. The following table gives their chemical constitutions and physical make-up.

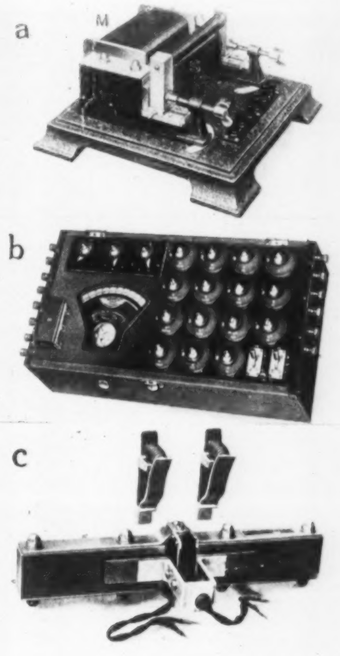


Fig. 1. Fahy's Simplex Permeameter (a); with control box (b), and adjunct (c) for testing materials in a strong field.

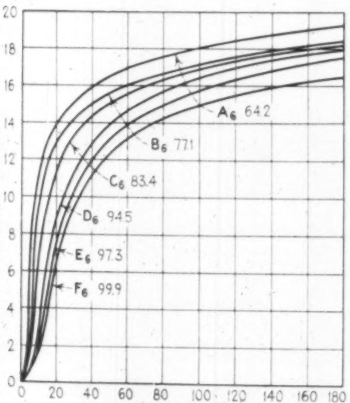


Fig. 2. Normal induction curves for the six rods.

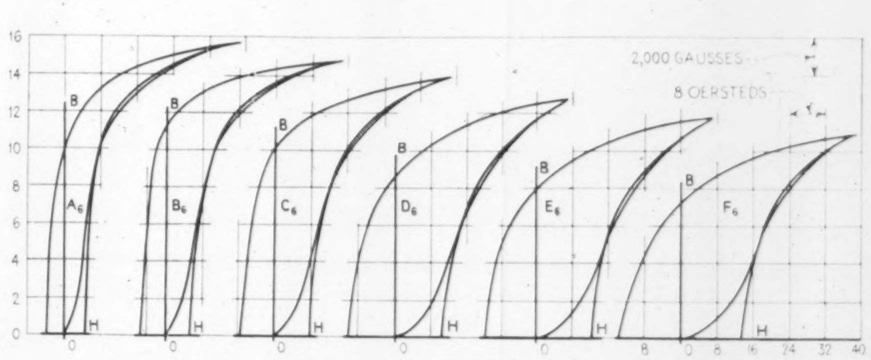


Fig. 3. Hysteresis Loss Curves for the Six Rods.

Only half of each loop is shown.
Curves for the six specimens are all drawn to the same scale.
Abscissas represent magnetizing force.
Ordinates represent induction.
H_{max} = 39.2 gilberts/cm.

The hysteresis loss in ergs/cm.^{3}/cycle for each rod is as follows:

A_6	19600	**D_6**	37760
B_6	26900	**E_6**	37600
C_6	32850	**F_6**	37400

---

*Fayerweather Laboratory of Physics, Amherst College, Amherst, Mass.

[1] Z. Jeffries and R. S. Archer, "The Science of Metals," page 403. McGraw-Hill Book Co., Inc., New York, 1924.

[2] H. G. Dorsey, "Magnetostriction in Iron-Carbon Alloys." *Physical Review*, Vol. 30, 1910, page 698.

C. W. Waggoner, "A Relation Between the Magnetic and Elastic Properties of a Series of Unhardened Iron-Carbon Alloys." *Physical Review*, Vol. 35, 1912, page 58.

E. D. Campbell and E. R. Johnson, "A Preliminary Magnetic Study of Some Heat Treated Carbon Steels." *Iron and Steel Institute*, Vol. 106, 1922, page 201.

E. D. Campbell and G. W. Whitney, "The Effect of Changes in Total Carbon and in the Condition of Carbides on the Specific Resistance and on Some Magnetic Properties of Steel." *Iron and Steel Institute*, Vol. 110, 1924, page 291.

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E. D. Campbell, "A Study of the Correlation of the Remanent Magnetism and Specific Resistance of Some Pure Iron-Carbon Alloys." *Transactions Faraday Society*, Vol. 21, 1925, page 1.

A. Kussmann and B. Scharnow, "Über die Koerzitivkraft." *Zeitschrift für Physik*, Vol. 54, 1929, page 1.

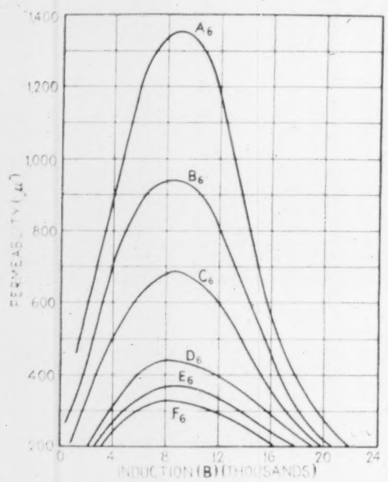

Fig. 4. Permeability Curves.

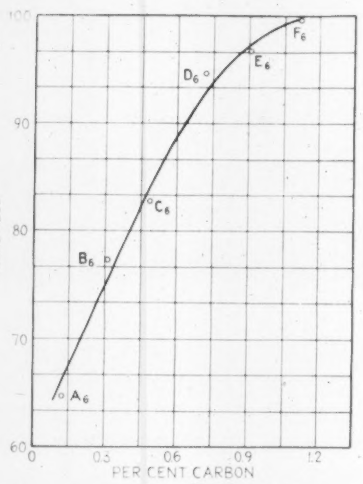

Fig. 5. Relation between Hardness and % Carbon.

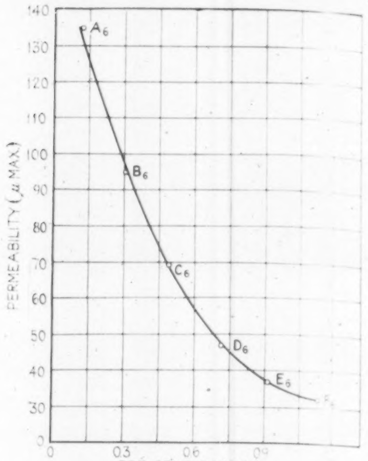

Fig. 6. Relation between % Carbon and Permeability.

Rod	Cross-sect. cm.²	Carbon %	Manganese %	Phosphorus %	Sulphur %	Hardness Number
A_6	0.326	0.11	0.49	0.010	0.039	64.2
B_6	0.325	0.31	0.53	0.012	0.039	77.1
C_6	0.320	0.49	0.41	0.012	0.033	83.4
D_6	0.318	0.69	0.48	0.019	0.033	94.5
E_6	0.322	0.91	0.44	0.023	0.027	97.3
F_6	0.320	1.11	0.42	0.019	0.036	99.9

The magnetic measurements were carried out by means of a Fahy's Simplex Permeameter. See Fig. 1. Quite complete directions for use accompany each instrument. The hardness numbers were obtained on a Rockwell hardness tester.

Fig. 2 gives the normal induction curves for the six rods. It will be observed that the induction increases progressively with the lowering of the hardness numbers. The softer the rod, the greater is the magnetic induction.

The hysteresis loops shown in Fig. 3 are of interest because they bring out a fact observed by the late Professor C. W. Waggoner[2] and others that the maximum hysteresis loss comes, for the iron-carbon series, near the eutectic point. For this series of rods, it is just about 0.9% carbon. For the harder rods the hysteresis loops were not carried above the saturation point. H_{max}, for the curves shown, was 39.2 oersteds. In curves not shown, the hysteresis loops were carried to $H_{max} = 180$ oersteds. The residual induction decreased with hardness. The coercive force (sometimes called "magnetic hardness") increases with increasing mechanical hardness.

Fig. 4 shows the permeabilities plotted against induction values. This shows, in a marked way, how the different samples varied in their permeabilities as the hardness numbers changed.

Fig. 5 sets forth the relation between the % carbon and the hardness number. This is not a straight line and therefore it will be of interest to compare the various magnetic properties with both the percentage of carbon and with the hardness numbers. From the curves, in Figs. 2, 3 and 4, were selected the various magnetic values with which the carbon contents and the hardness numbers were compared.

In Figs. 6 and 7, the maximum values of permeability are plotted against % carbon and Rockwell hardness numbers, respectively. Similarly, in Figs. 8 and 9, the hysteresis loss in ergs/cm²/cycle are plotted against % carbon and Rockwell hardness numbers respectively.

From these last four curves it would appear that the hardness numbers come more nearly to being proportional to the various magnetic properties than does the percentage carbon. Magnetic properties, as a measure of mechanical hardness, are, therefore, indicated as a possible means of hardness testing.

Some of the present day penetration methods for measuring mechanical hardness are simple in their operation. They are less time-consuming in their operation than the magnetic methods, which have been described. However, the importance of the present study lies in the possibility that it will ultimately lead to a clearer conception of what is meant by the term hardness. For example, Williams[3] has shown that the maximum elongations which steel rods undergo, when magnetized longitudinally (Joule Effect), are closely related to the hardness numbers of the same rods. This elongation is distinctly a deformation and, therefore, must bear some relation to hardness if the definition given by Jeffries and Archer has any significance. It is only as these various phenomena are studied and correlated that we may come to a clearer understanding of the main property to be studied, namely, hardness.

If a simple effective magnetic method can be developed for measuring mechanical hardness, it will have the decided advantage over the penetration method that it leaves behind no disfiguring marks on the sample tested: it may be applied to the finished product.

This work is to be extended to all sorts and degrees of hardness in which, for example, changes in electrical resistance in longitudinal magnetic fields and the Joule magnetostrictive effects will be compared with the mechanical hardness of the same specimens.

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[3] S. R. Williams, "A Correlation Between the Mechanical Hardness and the Magnetostriction Effects of Ferromagnetic Substances." *Transactions A. S. S. T.*, April 1924, page 362.

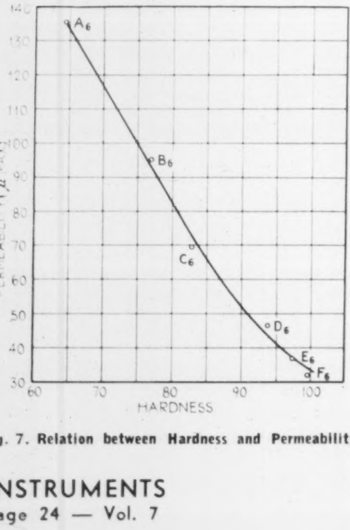

Fig. 7. Relation between Hardness and Permeability.

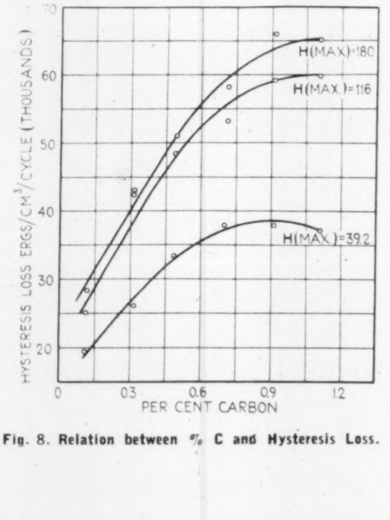

Fig. 8. Relation between % C and Hysteresis Loss.

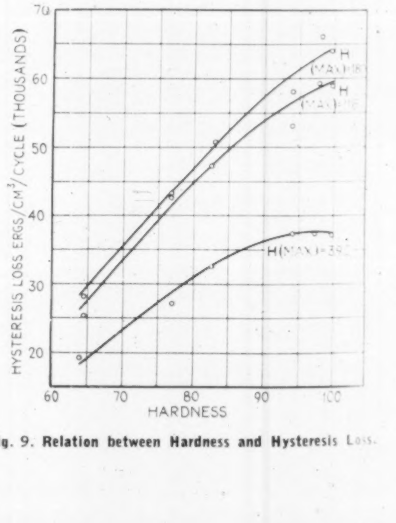

Fig. 9. Relation between Hardness and Hysteresis Loss.

The Metric System of Weights and Measures in Relation to Instruments

By A. E. KENNELLY*

IN view of the steadily rising demand for the increased use of international metric measures in instrument work, it seems desirable to define the existing situation of the metric system as regards scientific, technical and commercial practice.

It is quite generally admitted that the metric system is much easier to learn and use than the old American system, and it is used in very nearly all scientific work both here and abroad, and that it would be a great advantage if we had it universally. In the engineering world, it largely pervades both electrical engineering and chemical engineering, through the use of electrical and chemical units. In the commercial world, the American system is still used very largely; but the kilowatt-hour, the degree Centigrade, and the 16 mm. film are steadily invading it. In fact, unbiased inquiry into the history of the past thirty years in relation to American newspapers and magazines would probably satisfy the researcher that we Americans are already in slow transition toward the general use of the metric system even without any governmental direction or legislation.

What attitude, then, should be taken by technical and industrial journals on this question? The following views are suggested:

1. No person should be compelled to use units against his will. Nevertheless, as a majority develops in favor of metric units in technical and industrial practice, persuasion should be used to adopt international standards.

2. The demands of both basic and applied science for the simplest units and standards point to the exclusive use of the metric system whenever possible.

3. In the literature of commercial measuring instruments and apparatus, it often is undesirable to use metric units exclusively; but the practice of using both American and metric units, with their numerical values, should be encouraged (one of them in parentheses).

4. The standardization of machine or instrument dimensions helps the general introduction of the metric system. It does not matter whether the standardization is in American units or in metric units. A drawing or blueprint in either system can always be used for the other by simple slide-rule conversion with the ordinary ranges of mechanical tolerance.

5. It is a mistake to suppose that if the metric system were generally adopted it would be necessary to discard or abandon machinery in our factories. The same old drawings, tools, and machines would and should be employed to continue making the same sizes of product. In the sales departments, however, those products would be catalogued and sold in metric terms. The units and standards used in manufacture are matters of private concern to the maker. It is the buying and selling which is of international concern and requires conversion into metric terms. Not until drawings, tools and machines wear out and disappear would the question of replacement in metric numbers have to be taken up, and then it would be a matter of convenience and choice, not of necessity.

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*Professor Emeritus of Electrical Engineering, Harvard University, Cambridge, Mass.

NEWS AND NOTICES

On January 24, 1934, the Edison Medal for 1933 was presented by the American Institute of Electrical Engineers to **Dr. Arthur Edwin Kennelly**, Professor Emeritus of Electrical Engineering, Harvard University and the Massachusetts Institute of Technology, "for meritorious achievements in electrical science, electrical engineering, and the electrical arts as exemplified by his contributions to the theory of electrical transmission and to the development of international electrical standards." Dr. Kennelly, who was principal electrical assistant to Thomas A. Edison from 1887 to 1894, has published some 28 books of which he is sole author of ten; and has presented more than 350 papers before leading technical and scientific organizations. In 1902 he expounded a Theory on the Influence of a Conducting Layer in the Atmosphere on Long-Distance Radio Transmission which has resulted in the naming of the Kennelly-Heaviside layer.

Instruments naturally supposes that it is as President of the American Metric Association that Dr. Kennelly contributes the above article; but he also is Fellow, Honorary Member, and Past President, A.I.E.E.; Past President, Illuminating Engineering Society; Past President, Institute of Radio Engineers; Honorary Member, Institution of Electrical Engineers, London, of Société Française des Electriciens, of the Verband Deutscher Elektrotechniker E.V., and of the Institute of Electrical Engineers of Japan, of National Electric Light Association, and American Electrotherapeutic Association; Corresponding Member, British Association for the Advancement of Science; Fellow, Royal Astronomical Society, London; Member, National Academy of Science, American Physical Society, American Association for the Advancement of Science, Past Chairman of its Engineering Section; Member of the International Committee on Weights and Measures at Sèvres (1933); Fellow of the American Academy of Arts and Science; and many others.

Dr. Kennelly has received the following medals and awards: Institution Premium in 1887 and the Fahie Premium in 1889 from the Institution of Electrical Engineers, London; Longstreth silver medal in 1916 and Howard Potts gold medal in 1917 from the Franklin Institute, the Volta medal in 1927, and the Cross of a Chevalier of the Legion of Honor of France.

Giuseppe Faccioli, former works engineer and associate manager of the Pittsfield, Mass., works of the General Electric Co., died in Pittsfield, January 13, about four years after his retirement by reason of ill health. Born in Milan, Italy, in 1877, he came to this country nearly 30 years ago, following his graduation from the University of Milan. Here he was first employed by the New York Edison Co., became a designing engineer for the Crocker Wheeler Co., and later joined the railway department of the General Electric Co. In 1913 he was appointed works engineer of the Pittsfield plant, and in 1927 became associate manager. Mr. Faccioli spent considerable time at Schenectady, where he was associated with the late Dr. Charles P. Steinmetz, whose researches in the field of lightning were continued at Pittsfield by Mr. Faccioli and contributed largely to the success of the now famous high voltage laboratory there. Like Steinmetz, with whom his name was so often linked, Mr. Faccioli was a cripple. Unable to walk, he was wheeled around his laboratory and office.

The **General Regulator Corp.**, 50 Church St., New York, announce the election of the following officers: C. J. King, Pres.; R. A. Wright, Vice-Pres.; F. H. Plum, Vice-Pres. & Sec'y (who were formerly Pres., Sales Mgr., and Vice-Pres. respectively of the Smoot Engineering Corp.). J. W. Ackley is Treas. Under this management which has had 16 years' experience in the design, manufacture and operation of regulators and combustion control systems, the General Regulator Corp. is placing on the market a line of regulating equipment employing what is said to be a new stabilizing principle.

The newly formed **Wilbin Instrument Corp.**, 40 East 34th St., New York, plans to manufacture and market a complete line of electrical instruments for the control of temperature, humidity, pressure, vacuum and liquid level. Officers are Gus A. Binz, Pres.; Clement Wells, Vice Pres.; E. A. Heman, Director and Chief Engineer. Mr. Binz has been identified with the

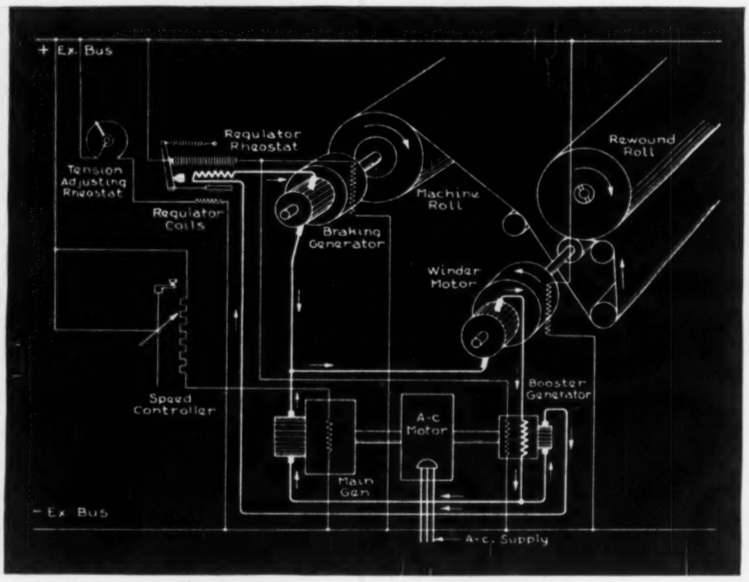
(Continued at Bottom of Next Page)

Paper Machine Control Developments

By H. W. ROGERS*

IN an industry as old and progressive as the pulp and paper industry, it is logical that current developments should generally be confined to improvements which will increase production, improve quality and reduce cost, rather than to those which will involve absolutely new ideas. Among the most promising recent improvements in paper mill equipment are two that demonstrate the benefits of automatic control. These are: an adjustable voltage winder drive with constant tension control and a paper cutter safety control.

Adjustable Voltage Winder Drive. In the use of electrical regenerating braking systems for the unwinding stand of paper machine winders, the maintenance of proper tension in the paper as it goes into the winder contributes materially to improving the characteristics of the rewound roll. It also serves to eliminate maintenance and avoid the loss of the power dissipated in mechanical braking.



The new equipment for this purpose (see schematic diagram) gives cushion starting, complete control of operating speed with good speed regulation at any speed, and substantial operating economy in the power consumed.

The braking effect on the unwinding reel is obtained by connecting to it through a gear reduction a generator whose armature output is fed back to the armature circuit of the winder motor. The current returned by this braking generator is proportional to the tension in the paper as it passes between the unwinding reel and the winder drum, and it is maintained constant.

Tension may be obtained in the paper with the winder at standstill and when operating at very low speed in starting a new roll. For automatic control of tension when starting a new roll, an auxiliary low voltage generator is supplied as a part of the main motor generator set. The armature of this booster generator is connected in series with the braking generator and has a voltage capacity just sufficient to compensate for the resistance drop in the armatures of the braking generator and the winder motor. Thus, excitation of this booster generator causes the current to circulate between the braking generator and winder motor and creates tension in the paper. The use of this booster generator eliminates the necessity for a winder attendant holding back on the winder rolls to keep slack out of the paper as the winder is being started and also assists materially in obtaining a firm centered roll as the winder starts up.

The control is so arranged that the braking generator may be operated as a motor in either the forward or reverse direction, thus eliminating considerable manual work on the part of the attendant in carrying the paper forward to the winder.

Power readings indicate that in addition to the benefits resulting from maintaining constant tension, the equipment provides considerable power saving, as approximately 50% of the current taken by the winder motor is returned by the braking generator.

Safety Control for Paper Cutter. To provide maximum protection for operators of guillotine type paper cutters, a Thrustor is arranged to engage the clutch mechanism which connects the knife to the flywheel and motor. Between the Thrustor and the clutch mechanism is a link with a solenoid-operated latch. The solenoid maintains the latch in the closed position and the Thrustor closes the clutch against the pull of a powerful spring. Two push button stations must be closed simultaneously so that both hands of the operator are occupied while the cut is being made. If the operator removes one or both hands from the push buttons, the solenoid is de-energized, the latch released, and the knife stopped. Cam-operated limit switches make it impossible for the cutter to repeat its stroke, even if the operator maintains his hands on the push button stations. The operator cannot block out one push button station and operate the cutter with the other one: it is necessary to release each push button station at the top of the stroke before another stroke can be made.

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*Industrial Engineering Dep't, General Electric Company.

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introduction of new measuring and control devices both in this country and in Europe. He has been Sales Promotion Manager of Sarco Company, Inc., for the last four years, and will continue his association with that company. Previously he was for nine years General Sales Manager of American Schaeffer & Budenberg Corp., and its successors. Clement Wells is President of Sarco Co., Inc. E. A. Ileman is a research engineer who has specialized in the development and design of industrial instruments for the last twenty years. The new company has contracted with Crosby Steam Gage & Valve Co. to manufacture its control instruments and valves.

The recently organized **Viking Instrument Co.** announces that it has begun production of a line of industrial instruments including (1) pressure and draft gages, (2) thermostats and humidistats, (3) tachometers and (4) electric motor speed controls. Some of these products were being manufactured by concerns merged into the new corporation. Offices are in the Chrysler Bldg., New York. A. C. Davis is Pres. and J. Leopold is Sales Mgr. Both were formerly with Consolidated Instrument Co. of America, Inc.

"For pioneering in industrial research," the **General Electric Co.** was presented on February 1 with a gold medal by the American Institute of the City of New York. The Institute's Council on Awards decided that the establishment and maintenance by GE of its large laboratory for pure research has been of lasting benefit to human progress and industry. The American Institute has not made an award of this sort for many years.

The Hays Corporation, Michigan City, Indiana, announces these new representatives: 1. T. C. Messplay, Kansas City, Mo. (State of Kansas and Western Missouri). 2. Fairman B. Lee, Seattle, Wash. (State of Washington). 3. Leinart Engineering Co., Knoxville, Tenn. (Eastern Tennessee). 4. Enginering Sales Co., Holland, Mich. (Western Michigan).

Donavon B. Church has been transferred from the San Francisco branch office to the factory engineering department by the **Mason-Neilan Regulator Co.,** Boston, Mass. Mr. Church has had many years' experience in the oil and process industries as a control engineer. He was formerly with the Neilan Company, Ltd., now consolidated in the Mason-Neilan Regulator Co.

A Modified Varley Phase Sequence Test

By G. W. STUBBINGS*

ONE of the most ingenious tests ever devised is the Varley test for phase sequence. The apparatus required is of the simplest, and the requisite information as to phase sequence is obtained by a direct visual observation of the comparative brilliancies of two lamps. The reliability of the test is not affected by considerable departures from balance of the three-phase voltage systems tested, although, with certain extreme conditions of unbalance, the test may fail and give erroneous indication. This limitation, however, is of little practical importance.

In the modification of the Varley test now to be described, the indication of phase sequence is obtained by a comparison of the voltages on a single lamp when the circuit is connected to the three-phase system in different ways. Such an indication is not quite so convenient as that of the direct visual observation of two lamps. Nevertheless, since the modified test gives correct indications which are quite independent of voltage unbalance, however great, it may be of some interest.

To explain the modified test we approach the theory of the Varley circuit from a somewhat unusual angle. In Fig. 1 (a), we have the usual vector diagram for a three-phase voltage system of normal phase sequence and, in this diagram, the direction of the voltage between A and C is conventionally represented as being from A to C. In this and the following diagrams the letters A, B and C represent actual terminals of the system under test, and are not intended to indicate phase sequence. In Fig. 1 (b), we have the vector diagram of a system of reversed phase sequence. The direction of the voltage between A and C terminals is from A to C, as in Fig. 1 (a), and it will be seen that, due to the reversal of the phase sequence, the second triangle of voltage vectors is inverted with respect to the first. The actual voltage difference between the B terminals of the two systems is thus $\sqrt{3}$ times the line voltage, if they are synchronized and joined in parallel by connecting the A and C terminals.

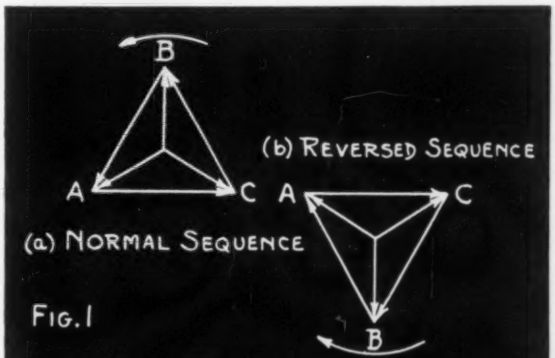

FIG. 1

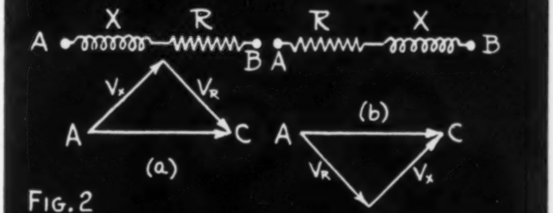

FIG. 2

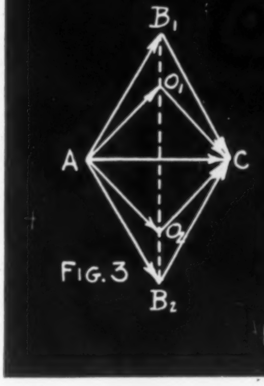

FIG. 3

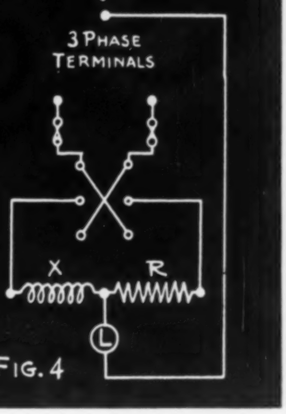

FIG. 4

In Fig. 2 (a) we have the vector diagram for the voltages on the component parts of a circuit comprising a reactor and a resistor of equal ohmic value connected between the A and C terminals of either of the systems represented by the vector diagrams of Fig. 1. Two conditions are shown, first, when the reactor is connected to terminal A, and second, when the reactor is connected to terminal C. It is seen that the applied voltage and the two-component voltage form a three-phase system the sequence of which reverses as the connection of the circuit to the supply terminals A and C is reversed.

In Fig. 3, the vector diagrams for the supply voltages and for the voltages on the reactor and resistor circuit are superimposed.

In this diagram the voltage differences between the common connection of the reactor and the resistor and terminal B of the supply system for various conditions are represented by the distances between the points B and o on the diagram. With normal phase sequence on the system and connections as in Fig. 2 (a), the voltage difference between the terminal B and the point of connection of the reactor and the resistor is represented by o_1B_1. With connections as in Fig. 2 (b) this becomes o_2B_1. If the phase sequence of the supply voltages is reversed, then these two voltage differences will be respectively o_1B_2 and o_2B_2. The voltage differences between terminal B and the common connection of the resistance and reactor can be compared by connecting a lamp between these points. The current taken by the lamp will, of course, alter the values of these differences, but the voltages on the lamp will give an indication of their relative values. With normal phase sequence of the supply system, for instance, so that the phase voltage of terminal C leads that of terminal A, the lamp will be more brilliant when the reactor is connected to C terminal than when this connection is to terminal A. It appears, also, that this indication will always be given correctly, irrespective of balance of the voltage system tested, for, with normal phase sequence, the point B in the vector diagram Fig. 3, will always lie above the line AC. If the phase sequence is reversed, the lamp will be brighter when the reactor is connected to terminal A than when this connection is to terminal C.

Fig. 4 shows the connections of a test circuit for the practical application of this modification of the Varley method of phase sequence determination. X and R are respectively a reactor and resistor, which should be of approximately equal ohmic values. These can be connected through a reversing switch and a pair of fuses to the pair of terminals whose phase sequence is required, a lamp being connected between the mid-point of the X and R circuit and the third terminal of the supply system.

The phase voltage of terminal A lags that of terminal C if the lamp is relatively dull when the reactor is connected to A. If the circuit shown in Fig. 4 be made up in portable form it will be easy to arrange the reversing switch so that its handle points to the lagging phase when the lamp is relatively dull.

The rule for the interpretation of the results of the above-described test can be checked by assuming that the resistor R is a lamp of the same rating as that of the lamp L. Assuming the phase sequence to be normal, and the reactor to be connected to terminal A, then the voltage on the lamp L will have a value less than that represented by the line o_1B_1 in Fig. 3. Of the two lamps the one connected to terminal C will be brighter than that connected to terminal B. This agrees with the well known rule for the Varley test, as the phase voltage of C lags that of B.

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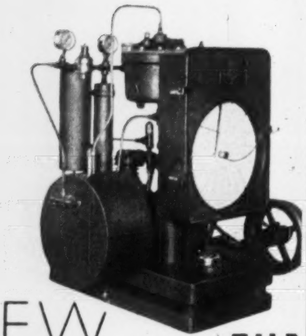
*Electrical Engineer, South Norwood, London, England.

The **Graybar Electric Co.** announces that it is now distributing the **Mercoid** line of control devices for regulation of temperature, pressure, etc., and that representative stocks are carried in numerous local branches.



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General Principles of Electric Currents

with reference to

Electrical Measurements and Control

By PERRY A. BORDEN†
and M. F. BEHAR**

1. Direct and Alternating Currents

Electric currents and all properties and phenomena associated with them are divided into two great classes, direct and alternating. The terms require little explanation. Direct current is that which flows continuously in one direction in the circuit, while the term "alternating" is applied to any current which periodically changes its direction of flow. Some types of instruments and apparatus respond to direct current only, some to either direct or alternating current and some to alternating current solely by virtue of the fact that it is alternating.

The ideal direct current maintains its value constant at every instant.

The change in flow of an alternating current may follow any one of an infinite number of laws; but before we can deal mathematically with any alternating current we must know the law which governs its changes of instantaneous values and of direction. The simplest law an alternating current can follow is the "harmonic" law, in which the instantaneous values of the current over a period of time are proportional to the sine of an angle; and this relationship is definitely associated with the geometry of the structure by which an alternating electromotive force is generated.

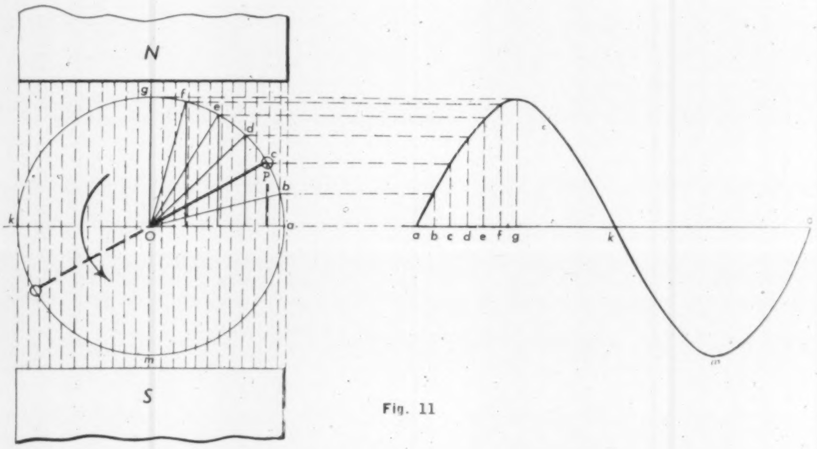

Fig. 11

In Fig. 11, imagine the line *OP* to represent an armature coil revolving between the poles NS. By following the curve at the right it will be noted that as the point *P* moves from *a* to *g* the induced e.m.f. gradually rises from zero at *a* to its maximum value at *g* since the coil when 90° from *a* is in the position of maximum induced e.m.f.; then, moving from *g* to *k* the e.m.f. gradually falls to zero. Continuing the revolution of the coil it is found (observing the curve) that the e.m.f. gradually rises from zero to its maximum value at 270°,

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*Second chapter (XXX) of Part Seven (Handbook of Industrial Electrical Measurements and Control) of Béhar's *Manual of Instrumentation*. See editorial announcement of this series on page A7 of November 1933 *Instruments*. A complete chapter of this new handbook will be published in each issue of *Instruments* throughout 1934 and 1935. Each chapter is subjected to a final revision, and then set in type, shortly before its appearance in this serial form, in order to assure that the subject matter is thoroughly up-to-date. This new book is not published serially in any other periodical. Entire contents copyright. To be issued in book form on or about Jan. 1, 1936.

†Member A.I.E.E.

**Editor, *Instruments*

but in the opposite direction, since the coil is now under the opposite pole. Thereafter the induced e.m.f. again falls to zero as the point P travels from m to a.

In an alternating-current generator having the ideal characteristics as suggested above, the e.m.f. appearing at the terminals of the armature would follow a true "sine law," and its successive instantaneous values could be represented by a wave-like curve as shown, each point of the curve corresponding to a definite position of the generating coil represented by the rotating line OP. It also is possible to represent graphically the values of the alternating entity by the line OP, which then becomes a "vector" (see below) and may be mathematically treated by practically all the processes of geometry and trigonometry. While actual commercial alternators do not generate true sinusoidal electromotive forces, their characteristic wave forms generally resemble so closely the true sine curve that the departure becomes negligible and the sine law may be applied with propriety, and either a wave or vector representation used, as may seem expedient.

2. Vector Representation

For purposes of computation where a sine wave may be assumed, it is customary to represent alternating quantities by revolving vectors. Referring again to Fig. 11, it will be observed that an abstract mathematical quantity of alternating character was represented by a rotating line symbolizing a simple coil in which a corresponding voltage would be induced. By carrying the analogy to the extent making the length of the line proportional to the maximum value of this mathematical quantity, we have the basis of a system of vectors by which even the most intricate alternating-current problems may be visualized and solved. As it is not within the scope of this Manual to provide a detailed discussion of vector geometry, only a few outstanding facts will be given, to facilitate the use of vectors in ordinary alternating-current considerations.

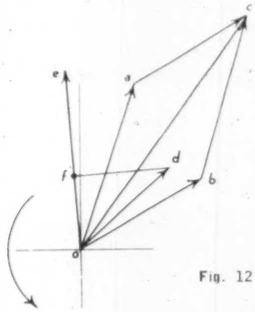

Fig. 12

The vector sum of *oa* and *ob* is represented by *oc*, the diagonal of the completed parallelogram.

The vector product of *od* and *oe* is proportional to the projection of one upon the other, as *of*, *f* being the foot of the perpendicular upon *oe* from point *d*. If *od* and *oe* be perpendicular to each other it will be seen that, whatever their linear values, their vector product will be zero.

(1) A vector is a line representing a mathematical quantity which has both a value and a direction. In Fig. 12, all the lines radiating from o are vectors.

(2) Vectors are generally assumed as rotating in a counter-clockwise sense.

(3) Vector quantities may be added or subtracted by "completing the parallelogram." See legend for Fig. 12.

(4) The product of two vector quantities is represented by the product of their linear values by the cosine of the angle between them, and is proportional to the projection of one vector upon the other. (Also explained in Fig. 12 legend.)

While the voltage wave of most modern power systems approaches so closely to a true sine law that any departure may usually be neglected, it does not follow that the current wave will be so free from distortion. Many causes combine to make the law governing current flow differ from that which governs the form of the voltage wave. Among these causes may be mentioned capacitors in the system, motors with peculiar regulating or compensating devices, gas and vapor tube lighting apparatus, electrolytic processes, arc furnaces and magnetization characteristics of iron in transformers and other inductive apparatus. It will be seen that no matter how intricate the mathematical law governing the flow of current, or how irregular it may be in its sequence of instantaneous values, it may be graphically represented as a wave; and it is in connection with electrical magnitudes which do not follow a sine law that the system of wave representation finds its widest use.

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INSTRUMENTS BOOK SHELF

Cathode Ray Tubes (Die Kathodenstrahlrohre und ihre Anwendung in der Schwachstromtechnik) By MANFRED VON ARDENNE with the assistance of DR. ING. HENNING KNOBLAUCH. Julius Springer, Berlin. Cloth, 6x9 inches, 398 pages, 432 figs. Price 36RM.

Although the low-voltage cathode ray tube is widely used in laboratory measurements and is gradually coming into prominence in the commercial field there has been no comprehensive book covering the broad field, to which a user of the cathode ray tube could turn for information. This book, although covering principally the work of German technicians, should be a considerable help to those interested in cathode ray oscillographs and their varied uses. It covers quite completely the theory of operation of the cathode ray tube and the various types of tubes available for specific uses. It also covers the various circuits and accessory apparatus used in connection with the cathode ray tube and goes into a large number of important applications of the tube for both laboratory and commercial use. The book is extremely well illustrated with photographs and diagrams of the behavior of the cathode ray, of the tube constructions, of the associated apparatus and of the observed waves.

There are four main parts. The first deals with the theory of operation of the cathode ray tube and with details of tube constructions. Some of the subjects discussed are, general terms, state of the art, production of cathode rays, ionization tubes, hot cathode tubes, focusing of the beam by outside fields and by gas focusing, various methods of modulating the beam, various methods of deflecting the beam, tube construction in general, the fluorescent screen and tubes for special work.

The second section deals with accessory apparatus. This includes methods of obtaining supply voltages for the tube, amplifiers, methods of obtaining the deflecting voltages from phenomena under observation, various types of sweep circuits and considerable data on various methods used in photographic recording.

In the third section, devoted to laboratory applications of the tubes, the following subjects are discussed. Study of transient and periodic phenomena; in testing condensers, electronic tubes, rectifiers, amplifiers, loud speakers, radio transmitters and receivers and in the determination of radio wave field strength and direction. In addition specialized applications in telegraphy, telephony, high voltage testing, acoustics, ballistics, internal combustion research and medical research, are discussed.

The last section deals with the application of the cathode ray tube to sound recording on motion picture film and its use in television. A rather complete bibliography and index are also included.

Because of the many excellent illustrations and diagrams in this book it is possible for a person unfamiliar with the German language to obtain much useful data from it. However, it is to be hoped that it will be printed in English, which would give it a much wider acceptance in this country.

—ALLEN B. DU MONT (7.8)-**B**-

At the January 29 meeting of the New York Electrical Society it was revealed by Dr. Orestes H. Caldwell, president of the Society and editor of *Electronics*, that the Society's meeting of February 22 will be devoted to showing how "Science Makes More Jobs." To combat propaganda destructive to science and research, Dr. Karl Compton, chairman of President Roosevelt's Science Advisory Committee, and president of Massachusetts Institute of Technology, will tell of the many ways in which research

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While the wave shown in Fig. 11 is a true sine curve, those shown in Fig. 13 are representations of somewhat hypothetical currents, that at "A" being a rectangular wave such as might be obtained from a periodically reversed direct current and that at "B" a triangular wave, of a type which would practically never be met with in actual practice. The wave at "C" in Fig. 13, however, while far from being a sine wave, is of a form frequently encountered, actually representing the flow of magnetizing current in a transformer while that at "D" on the same oscillographic record is the voltage across the terminals of the same transformer. This was a commercial voltage and its form is fairly typical and closely approximates a sine wave.

3. Average Value

In the measurement of periodically varying magnitudes it is important to distinguish among several different mathematical conceptions which may apply to those magnitudes. The instantaneous value of an alternating current is of course the value at any chosen instant of time, and in most alternating currents this value is not the same in two successive instants. Since half of the instantaneous values are negative and half are positive, and since the negative values are exactly equal to the positive values, the average of a complete cycle would be zero; and, as will be shown later, an instrument which measures only the *average* value of an electrical magnitude will give a zero indication if that magnitude be alternating. The *average* value of an alternating current is little used except in computations. When it is employed it is generally taken as the average of all instantaneous values *regardless of signs;* and it may readily be determined from the wave by plotting a number of instantaneous values throughout the cycle and finding their average. Or the average may be computed from the equation by calculus. It is found that for a sinusoidal wave the average value is 0.6371 × the maximum value.

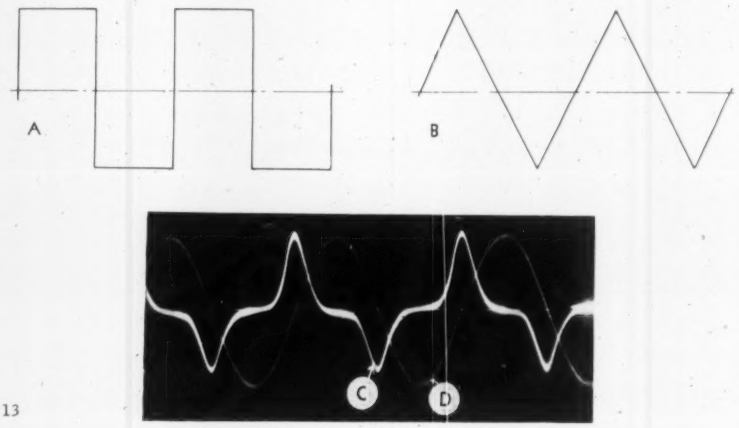

Fig. 13

4. R.M.S. Value

The *effective* value of an alternating current is not the average of the instantaneous values of the current. The strength is defined by the heating effect. An alternating current and a direct current are said to be equal if they produce heat at equal rates when they flow through equal resistances. An alternating current is said to have a strength of one ampere when the average rate at which it produces heat in a given resistance is equal to the rate at which heat is produced by a direct current of one ampere when flowing through an equal resistance. The heat produced by an electric current is proportional to the square of the value of the current. Therefore, the effective current in a circuit is obviously proportional to the square root of the average value of heat produced by that current. Now, since the rate at which heat is produced at any instant is proportional to the square of the value of the current at that instant, it follows that the effective value of an alternating current is represented by the square root of the mean of the squares of the instantaneous values. This is known as the *root-mean-squared* (r.m.s.) value of current. Obviously an alternating voltage, as well as an alternating current, is measured by the square root of its average square value. It is found that for a sinusoidal wave the root mean-squared value is 0.707 × the maximum value. Hence the ratio between the effective and average values is $0.707/0.6371 = 1.11$, which value is known as the *form factor* of a sine wave. Form factors vary greatly with different shapes of waves; but it is possible for two waves having totally different wave forms to have equal form factors.* That a particular wave form has a form factor of 1.11 does not necessarily mean that it is a true sine wave.

Since the magnetic effect in a system where the sole source of field is a single current is proportional to the square of that current, it follows that the relationship existing between instantaneous and other values of an alternating current is the same when determined on a basis of electromagnetic effects as on a basis of heating effects.

The universal method of defining the strength of alternating currents by the square root of the average square value has the following advantages:

(*a*) It makes possible the measurement of any alternating current, of whatever wave form, by its heating effect.

(*b*) It makes electromagnetic instruments available for the measurement of alternating currents, and also for power measurements.

(*c*) It brings alternating currents under the same laws of heating as direct currents.

(*d*) It avoids the necessity of a factor in the expression for power, which would be different for each wave form.

In general the two halves of an alternating current are symmetrical about the zero line; but in some cases they may differ. The wave on one side of the zero line may be flat and the other peaked. But in true alternating current the *average* values of the halves of the wave are identical. If the average values are not identical it follows that a direct-current component is present; and such a wave may be said to be a mixture of direct and alternating current. A pulsating or rectified current may be said to consist of such a mixture. In the measurement of such currents special considerations are necessary, and these are treated in a later chapter. In general it may be said that when a direct and an alternating current, or two alternating currents of differing frequencies, are mixed in a circuit, *the effective value of the resultant current is equal to the square root of the sum of the squares of the effective values of the component currents.*

5. Power

In the same way as the power in a machine may be defined as the product of the force by the distance through which it acts, the power in an electrical circuit is represented as the product of the voltage across the terminals by the current flowing in the circuit. With direct current this conception presents no difficulties; and in alternating-current considerations where the current and the voltage are exactly in phase, *i.e.*, where they go through their respective zero value, maximum value and all other values at exactly the same moments in the cycle, the power is represented by the product of effective values of current and voltage. Owing to circuit conditions, the current in an alternating-current circuit is more often than not out of phase with the voltage, the current leading, or more probably lagging, the voltage by a certain periodic time. In such cases the true power in the circuit is no longer the product of the current and the voltage. This will be better understood by reference to Fig. 14. The value of power at any instant is represented by the product of the instantaneous current and the instantaneous voltage. This product is at all times positive, and its representation, the wave w, is at all times on one side of the zero line and is of double the frequency of the component parts. The power flow, therefore, is unidirectional; and the real value is represented by the *average* height of the curve as referred to the original zero line.

The quantity by which the product of effective value of current and effective value of voltage must be multiplied to obtain true average power as distinguished from "apparent power" is known as *power factor*; and where sinusoidal waves only are concerned, it may be defined as the cosine of the phase angle between the current and voltage. When the current reaches its respective values later in the cycle than the voltage, the power factor is said to be *lagging*, and when earlier, *leading*.

The value of power factor may vary between $+1$ and -1; but it is generally expressed in percent. If the power factor of a circuit has a negative value it signifies that power is being transferred in a direction opposite to that considered as normal; and the circuit may be said to be "back-feeding." The power factor of a circuit in which the current and voltage are not of the same wave form can never reach 100 percent. Since the power factor of a circuit is equal to the ratio of the true power to the volt-amperes, power factor might be defined as the ratio of the actual power to the maximum power that could be obtained with a given current and voltage.

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*R. R. Lawrence. Principles of Alternating Currents, page 106.

and invention have created new industries employing hundreds of thousands. Among other distinguished speakers will be Dr. R. A. Millikan, the isolator of the electron, and Dr. Kettering, director of research for General Motors. The meeting of February 22 will be held in co-operation with the American Institute of Physics, and the New York Museum of Science and Industry, 220 E. 42nd Street, New York, will also co-operate by setting up a special free exhibit of inventions showing the many millions of man-hours of employment which each has produced.

The Fourth International Congress for Applied Mechanics will be held in Cambridge, England, July 3 to 9, 1934. Subjects to be discussed will be grouped under the four general headings: (1) Rational Mechanics, including vibrations of structures and machines. (2) Mechanics of Fluids, including turbulence, the boundary layer, heat transfer, and compressible fluids. (3) Materials, including elasticity, plasticity, fatigue, and crystal structure. (4) Water Waves, including resistance and stability of ships and seaplanes. Inquiries regarding the Congress and promises of manuscripts should be addressed to the Applied Mechanics Division of the A.S.M.E., 29 W. 39th Street, New York. Summaries about 300 words in length, written in English, German, French, or Italian, will be required about April 1, 1934. All those who intimate their intention of attending the Congress will receive, early in 1934, a further notice giving details of the arrangements.

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MANUFACTURERS' NEW LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

B26 **Control Units.** Loose-leaves 14 on Proportioning System of Automatic Control, and 125 on motorized valves. Also folder entitled "Reducing Factory Costs." Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

B27 **Foot-candle Meter.** Leaflet on the "Sight Meter." The Sight Light Corp., New York City.

B28 **Flow Meters, etc.** Broadside entitled "Measurement & Control of Gas, Air, Steam, Oils, Fluids." American Meter Co., New York City.

B29 **Industrial Instruments.** 40-page Bulletin 390 pictures and briefly describes entire line of indicating, recording and controlling instruments. The Bristol Co., Waterbury, Conn.

B30 **Analytical Balances.** 44-page Catalog B1 contains complete descriptions of various "Sartorius" analytical balances; also catalogs miscellaneous laboratory supplies. Pfaltz & Bauer, Inc., New York City.

B31 **Microscopes.** Several bulletins on the "Reichert" line. Pfaltz & Bauer, Inc., New York City.

B32 **Flow Meters.** 24-page Catalog 700 describes new models of electrically operated flow metering systems with "cartridge sealed element" instruments. Republic Flow Meters Co., Chicago, Ill.

B33 **Room Temperature Control.** Leaflet SA 402 on the "Thermochron" electric clock thermostat. Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

B34 **Laboratory Instruments and Apparatus.** 12-page Circular No. 4 announces standard model A apparatus for low-temperature fractional distillation; Circular No. 5 describes glass blowing and special scientific apparatus; 12-page Circular No. 7 announces high-temperature fractional distillation apparatus; also catalogs entitled Price Lists No. 40, No. 60 and No. 70 describing accessory instruments. Podbielnak Analytical and Research Labs., Chicago.

B35 **Laboratory Ovens.** 4-page bulletin describes new models with horizontal-flow forced-air circulation. Freas Thermo-Electric Co., Irvington, N. J.

B36 **Humidity Recorder.** Bulletin 413 (folder) describes portable "Humidigraph." The Bristol Co., Waterbury, Conn.

B37 **Automatic Sizer.** 4-page bulletin describes air-operated device and control box for regulating grinding operations. Landis Tool Co., Waynesboro, Pa.

B38 **Cenco News Chats.** December 1933 number contains technical articles on the Photelometer, on conductivity measurements, on ultra-violet fluorescence demonstrations; and describes new models of instruments. Central Scientific Co., Chicago, Ill.

B39 **The Experimenter.** November 1933 number contains articles on cathode ray oscillographs, direct capacitance and its meaurement, etc.; December number's leading article is on improvements in r.f. bridge methods for measuring impedances. General Radio Co., Cambridge, Mass.

B40 **Convertible Microscope.** 4-page bulletin describes "L" stand and its accessories. Carl Zeiss, Inc., New York City.

B41 **Dark Ground Illumination.** 20-page booklet describes several types of accessories for this purpose. Carl Zeiss, Inc., New York City.

B42 **Temperature Control.** Bulletin No. 5 (folder) describes relays, relay control units and thermoregulators. Central Scientific Co., Chicago, Ill.

B43 **Recording Pyrometer.** Folder illustrates and briefly describes potentiometer pyrometer. The Brown Instrument Co., Philadelphia, Pa.

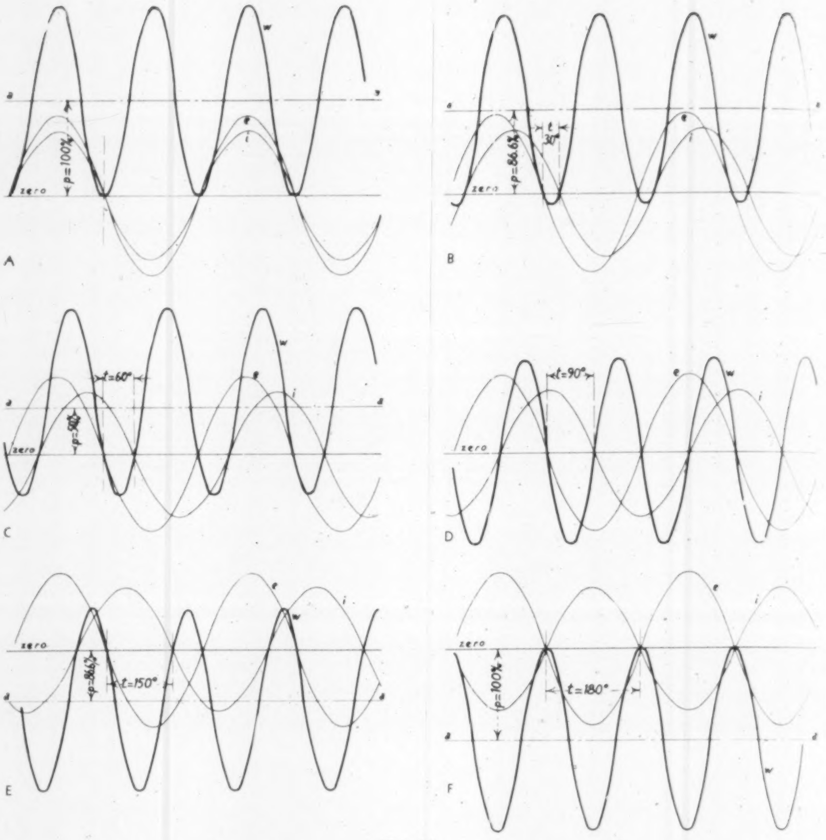

Fig. 14

The above sketches will enable the reader to visualize the voltage, current and power relationships corresponding to different relative phase positions between alternating quantities in a two-conductor circuit. Voltage values being represented by the curve e and current values by i, the value of power at any instant is proportional to the product of their respective instantaneous values.

At **A**, which represents the "in-phase" condition, it will be seen that the two quantities, voltage and current, are always of the same sign, either positive or negative, and that hence the product of these—the power—will at all times be positive, the power being represented by the curve *w*, which is at all times on one side of the zero line. (In the case of both current and voltage being sine waves, the power wave is also a sine wave, having twice the frequency of the others.) The power flow, therefore, is unidirectional, and the real value is represented by the *average* height of the curve *w* as referred to the zero line, i.e. by the perpendicular distance *p* from the axis of symmetry a—a of the power wave to the zero of reference.

At **B** is represented a condition where the current and voltage are not in phase with each other, the current now lagging the voltage by a time *t*, which represents one-sixth of a half-cycle or 30 electrical degrees. Here it will be seen that while the shape and size of the power wave *w* have not been altered, part of the wave—that part corresponding to the time in the cycle when the current and voltage are opposite in sign—has become negative, so that the average value, the true power, is lessened, and the distance *p* is found to have 86.6% of its original value, which amount corresponds to the cosine of an angle of 30°.

At **C** is shown the condition when the current lags the voltage by 60 electrical degrees, when it will be seen that the net result, as affecting the power wave, is that the axis of the wave approaches more closely to the zero of reference, the value of *p* now being 50% of its original value.

At **D** the current wave passes through its zero values at those instants when the voltage is passing through its maximum and minimum values, the respective quantities thus being in quadrature relationship, corresponding to an angle of 90 electrical degrees. Here it will be seen that the power wave is evenly distributed about the zero line, so that its axis of symmetry concides with the latter, making its average value equal to zero and giving the condition known as *zero power factor*.

If the phase displacement is still further increased, as at **E,** the negative values of power become greater than the positive and the power flow becomes negative. In other words the power flow has been reversed; and if, as at **F**, the two component waves are in exact phase-opposition, the power flow has a negative value equal to the original positive value.

—

6. Polyphase Systems

Since practically all present day alternating-current distribution systems are of the polyphase type it is necessary that a clear understanding be had of the underlying principles of polyphase circuits, in order to perform measurements and calculations thereon. For reasons both technical and economic it is found desirable that alternating current generators and motors (excepting in very small sizes) instead of having but one winding as indicated in Fig. 11, have a number of similar windings evenly distributed about the armature. As these windings will successively pass through their positions of maximum induction, zero induction, etc., at different times, it will be seen that the voltages induced in them will likewise differ in time-phase position. While various phase relationships have been used, the present-day practice is almost universally three-phase, there being three distinct windings having independent voltages generated in them, these windings being connected on one another and to the outside circuit in various ways. A three-phase alternator may be considered as consisting of three single-phase generators having equal electromotive forces maintained at successive phase-displacements of 120 degrees. In Fig. 15 these three alternators are shown, connected one to each of three line wires, their other terminals being joined to form what is known as the *neutral point* of the system. This so-called "Y-connection" is visualized in Fig. 16, a diagram generally used to represent a three-phase alternator. The corresponding vector diagram is shown in Fig. 17.

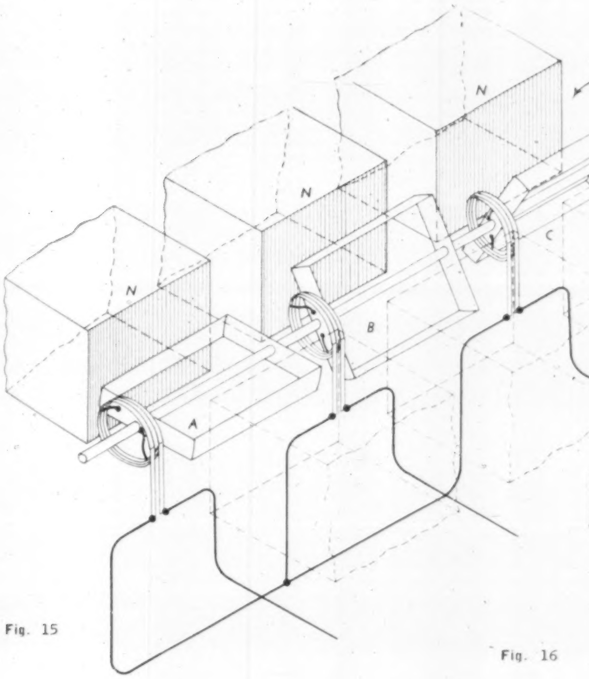

Fig. 15

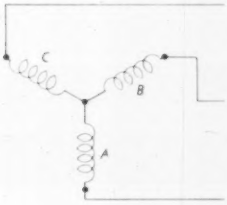

Fig. 16

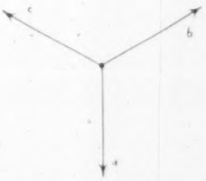

Fig. 17

Fig. 15 does not show the actual construction of any polyphase alternator. In practice, the windings would be placed on a common core in the field of a common magnetic system. Moreover, such alternators are only used in laboratories: the alternators used in power plants have stationary armatures and rotating fields.

In Fig. 18 (where the remainder of the alternator must be imagined) are indicated the corresponding conditions for a different connection of the three single-phase units. Here the three generators that make up the alternator are connected in delta, thus forming a mesh- or delta-connected system† conven-

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†For detailed discussion of phase and vector relationships in these diagrams, see "Swoope's Lessons in Practical Electricity." E. Haussman. XVIIth Edition, 1926. Pages 515-516.

B44 **Flow Controller.** Broadside illustrates and describes "Dampliffier" system of control and TAG flow meter. C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

B45 **Instruments for Glass Control** is title of folder on polariscope, etc. Bausch & Lomb Optical Co., Rochester, N. Y.

B46 **30 Years of Progress** is title of booklet commemorating Ford Exposition of Progress. Ford Motor Co., Dearborn, Mich.

B47 **Indicating Pyrometer.** 4-page Bulletin 192 announces indicating potentiometer pyrometer and multiple switch. The Foxboro Co., Foxboro, Mass.

B48 **Ohmite News.** December 1933 issue has article on voltage divider resistance values. Ohmite Mfg. Co., Chicago, Ill.

B49 **Radio Tester.** Bulletin 611 describes No. 611 Universal Tester and Set Analyzer. Shallcross Mfg. Co., Collingdale, Pa.

B50 **Filtration Funnels.** Folder (in German) describes new form of glass funnels and filter disks therefor. Fish-Schurman Corp., New York City.

B51 **Stopcock Plug and Bottle Stopper Remover.** Bulletin 510 describes this new device. Eimer & Amend, New York City.

B52 **Radiation Pyrometers.** 8-page bulletin describes theory of operation, and maker's tubes and instruments. Thwing Instrument Co., Philadelphia, Pa.

B53 **Scientific Instruments.** 24-page catalog "Galvo 33" describes galvanometers, photographic recording apparatus, and galvanometer accessories. P. J. Kipp & Zonen, Delft, Holland.

B54 **Remote Liquid Level and Pressure Recorders and Indicators** are described in 8-page Bulletin 900. Republic Flow Meters Co., Chicago, Ill.

B55 **Pressure Indicators.** 4-page Bulletin 800 describes multi-point draft and low-pressure indicators. Republic Flow Meters Co., Chicago, Ill.

B56 **Convertible Microscope.** Folder describes basic model "HS" and additional parts. Bausch & Lomb Optical Co., Rochester, N. Y.

B57 **Instruments for Metals.** Price list effective December 27, 1933, on optical instruments for examining and analyzing metals. Bausch & Lomb Optical Co., Rochester, N. Y.

B58 **Heating Elements.** 16-page booklet entitled "Spots of Heat for Industrial Plants." General Electric Co., Schenectady, N. Y.

B59 **Glass Tubing.** Bulletin 4548-E describes new-process precision bore Jena glass tubing. Fish-Schurman Corp., New York City.

B60 **Precision Devices.** 72-page Catalog 6-1934 describes dial indicators and comparators, limit gages, etc.; 42-page catalog on Johansson gage blocks, gages, accessories and reference tables. (Standard Gage Co.) Louis C. Eitzen Co., New York City.

B61 **Steam Traps.** 20-page catalog entitled "The Solution of Your Condensation Problem." Nason Mfg. Co., New York City.

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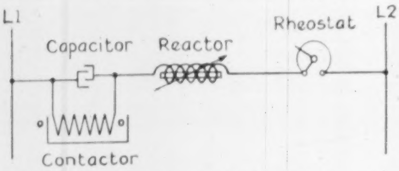

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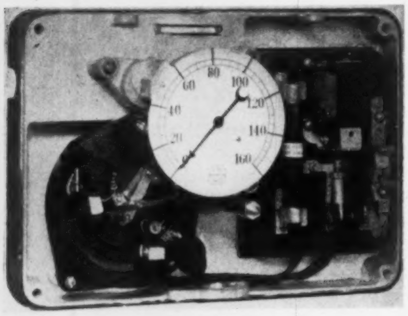

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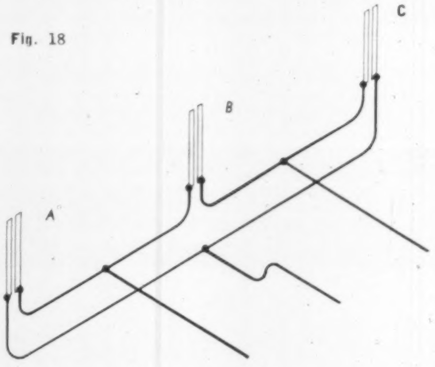
tionally represented in Fig. 19, and having a vector diagram as shown in Fig. 20.

The order in which the several phase voltages of a polyphase system reach their maximum values is referred to as the "phase rotation" or "phase sequence" of the system.

The power in a polyphase system may be considered as the sum of the power components in the several windings of the generator or its equivalent. Considering the Y-connected machine in Fig. 15, and assuming that the three voltages are equal to one another, and that equal currents I are drawn from the three windings, since the power in each phase winding is represented by the equation $W_1 = E_1 I \cos \phi$, the total power will be represented by $W = 3E_1 I \cos \phi$, or, since the line voltage E_{ab} is equal to $\sqrt{3}\, E_1$, $W = \dfrac{3E_{ab} I \cos \phi}{\sqrt{3}} = \sqrt{3}\, E_{ab} I \cos \phi$. By a similar reasoning it will be seen that exactly the same law applies to the delta-connected system, so that in general the power in a three-phase circuit where a balanced load exists may always be expressed as $W = \sqrt{3} EI \cos \phi$.

Fig. 18



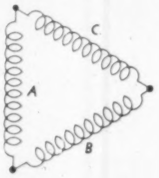


Fig. 19

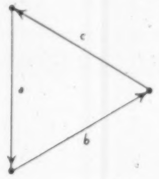


Fig. 20

In the foregoing expressions for power in a three-phase system, assuming a balanced load, it is evident by transposition that the value of power factor is represented by the expression $\cos \phi = \dfrac{W}{\sqrt{3} EI}$.

7. Considerations of Unbalanced Loads

While in the ideal polyphase system the line voltages are equal in magnitude and evenly spaced in time relationship about the cycle, and while in practice this ideal condition is generally approached to a degree that errors may be neglected, the same does not hold true for the current values in the several lines or phases. When the currents are unequal the load is said to be unbalanced; and measurements of such loads present some special problems which require consideration. As in the balanced load, the total power in an unbalanced load is represented by the sum of the power elements in the several phases considered individually. The power factor of an unbalanced load, however, is an indeterminate quantity; and its true significance has been made the subject of much controversy. The basic difficulty lies in finding a true definition of "volt-amperes" as applied to such a load. While from a truly mathematical standpoint the controversy may never be settled, certain conventional methods of representing and determining an equivalent quantity have been used and generally accepted; and these will receive further consideration in the August instalment of this series.

WANTED

DEVELOPMENT ENGINEER — To take charge of Engineering Department in well established concern. Must have decided inventive ability and original ideas. Man with background in process industries, preferably experienced in the automatic control field. Must be capable of executive and management duties. Give full qualifications in your reply, which will be treated confidentially. Box M, INSTRUMENTS, 330 W. 42nd Street, New York, N. Y.

POSITION WANTED

SALES ENGINEER — With ten years of experience in maintenance, sales research and sale of industrial instruments and controls. Technical education. Thoroughly understands industrial selling. Now employed, with authenticated sales record made during depression. Can furnish references from most important buyers in his territory. Would like to connect with live organization that will grant income commensurate with results obtained. Address Box H, INSTRUMENTS, 330 West 42nd Street, New York, N. Y.

field of such observations there has been brought out a portable equipment (size of small suitcase) which magnifies to 10^6 or 10^7 the localized sounds in products being tested. An attachment lets user verify the sensitivity of his own ears at any time, to make sure that unusual sounds are not subjective as in the case of head colds. Another attachment is a filter for selecting desired frequency range and excluding extraneous sounds. In addition to the testing of welds, leather, catgut, etc., the equipment is said to be applicable to medicine, watchmaking, the study of fluid flow in engines, pumps, fittings, etc.

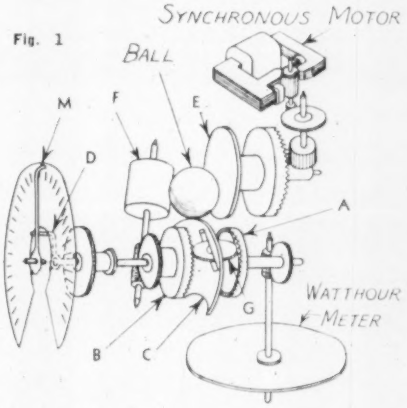
A New Type of Demand Meter

By B. H. Smith*

THOUGH gas is sold by the cubic foot, water by the gallon and electricity by the kilowatt-hour, the cost of producing and delivering them is not strictly proportional to quantity. Especially with electricity, the cost of serving a customer who runs a 100 h.p. motor for one hour a day is much greater than for one who operates a 10 h.p. motor ten hours a day, though both use the same number of kwh. The 100 h.p. motor requires a larger generator, heavier cables and larger transformers, switches, fuses and protective apparatus at several points along the line. Hence the "demand charge." This should be based on the highest load for a short time period, say 15 or 30 min., which occurred during the month, but may not necessarily be fixed by the actual number of kwh. used during that period. One index of demand is the temperature of apparatus in the circuit. Satisfactory demand meters are available which themselves operate on the heating principle and produce a temperature in their mechanisms and a reading on their dials which on steady loads is directly proportional to the load, and on variable loads is proportional to the heating value of those loads. It is the purpose of this article to describe a new demand meter which follows the same law as the "heat storage" or thermal meter, yet whose operation is purely mechanical and is not subject to errors in thermal meters due to (1) physical limitations of available materials and (2) the fact that escape of heat is not exactly proportional to temperature.

Fig. 1 is a perspective outline of this new meter. A and B are small crown gears which with planetary gear G form a differential which, through the relative speeds of its parts, controls the angular position of involute cam C. The cam is mounted on a shaft which connects with demand pointer D. A solid aluminum ball rests against the edge of cam C and is positioned between driving disk E and driven drum F. At the zero position of the cam, the demand pointer is at zero on the scale and the ball is held at the exact center of driving disk E. Gear A of the differential is driven by the watthour meter; gear B by drum F of ball mechanism. As long as there is no load on the watthour meter, and if the ball is at the zero position, the differential remains at rest and driving disk E simply rotates at a constant speed due to a connection with the synchronous timing motor, but no motion is imparted to the ball and the demand pointer remains on zero. Now, if a load is applied to the watthour meter, its side of the differential is driven at a speed proportional to this load, the cam begins to move, and since drum F is tilted at a slight angle, the ball follows the cam and moves a little away from the center of disk E. Immediately the ball begins to rotate about an axis which is parallel to the drum and which passes through the contact point between the ball and cam so that there is no friction at this point to prevent free rotation. Since the ball is resting on drum F and rotating about a parallel axis, the drum is driven at the same surface speed as the ball and in turn drives gear B in a direction arranged to be opposite that of gear A. Thus the motion of planetary gear G with cam C is equal to the difference between A and B; therefore, if for any position the speed of B is equal to A, the cam remains stationary in that position. Referring again to the position of the ball against driving disk E, it is evident that the rotational speed of the ball and, consequently of drum F, is proportional to the angular position of the cam since the radius or "rise" of the involute cam is exactly proportional to its angular position. Then for any given load and corresponding r.p.m. of A, there is a definite position of cam which will give an equal and opposite speed of B. The cam moves until this balance point is reached and there remains until the load on the watthour meter changes to a new value.

Fig. 1



Since the *rate* at which the cam with the demand pointer D moves is equal to the difference in speed between A and B, it is evident that this rate starts off at a relatively high value, then becomes less and less as A minus B approaches zero, and the time to fully reach the balance point is very long. Thus the advance of D over the demand scale is rapid at first but becomes less and less as the final position is approached. For the same change in load, the descending rate as the demand pointer returns to zero is exactly the same as the ascending rate. Thus, if the watthour meter stops, gear B simply continues to rotate and carries the cam in the reverse direction at a slower and slower speed until finally the ball is again at the center of disk E and all motion stops. All of the above is analogous to a thermal meter where the pointer moves at a constantly decreasing speed or rate until the escape of heat just balances the heat input due to the watts in the circuit being measured. In both cases if any load is applied the time t to reach any point a on the scale is given by the equation $t = T \log_e \frac{b}{b-a}$ where b is the final reading and a is some percentage of that reading and T is the time which would be required to reach the former balance point in the thermal meter if there were no escape of heat. Then, if the 90% point is selected, the equation becomes $t = T \log_e \frac{100}{100-90}$ or $t = 2.302\ T$. Since it is impossible to avoid the escape of some heat, the time element of a given design of thermal meter may only be determined and adjusted by experiment after first building a model and operating it with various adjustments until the desired value of t is found from which the value of T may be calculated. In the new mechanical logarithmic meter under discussion, however, we may simulate the desired condition by simply stopping the synchronous motor. Then the watthour meter will carry forward the cam with its attendant demand pointer at a constant speed and will reach a given point in a time which is determined by the gear ratio between the watthour meter and the demand pointer, and which is the value of T in the above equation.

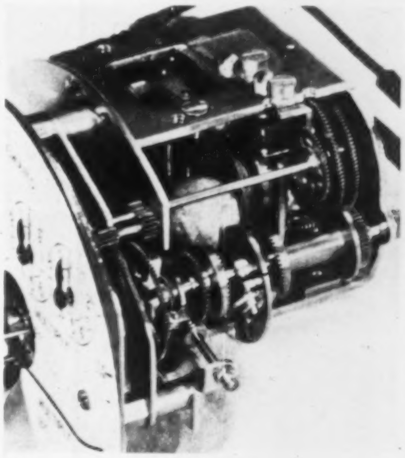


Fig. 2

It is easy to check the time element and general condition of this meter, whatever its momentary reading or connected load may be: the demand pointer is manually reset to zero at will (since this operation merely slips a friction clutch between the watthour meter and the differential) and the time necessary to reach a given indication is measured with a stop watch. Thus is avoided the long wait which would be necessary if the meter had to be disconnected from the load and allowed to return itself to zero along its normal logarithmic curve.

Operation is smooth and continuous; there is no tripping or sudden resetting of parts which might cause them to get out of order. As to whether there is any slipping of the ball: tests were made with the maximum hand friction adjustment tightened up until the torque required to move it was many times normal, yet there was no measurable error in the r.p.m. of the ball side of the differential. The other operations involve only well-known mechanical elements, such as gears, pinions, differentials and a low-speed type of synchronous motor.

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*Meter Engineer, Westinghouse Elec. & Mfg. Co.

"Metameter" Remote Recording System

The Bristol Co.

CHART records of pressure, liquid level, temperature (or other measurable condition producing a deflection of a standard Bristol measuring element) can be obtained at any distance up to 250 miles by means of this new system. At the sending end there is a transmitter said to require practically no attention; at the receiving end of the two-wire line there is a "relay and rectifier box" (containing simple elements) in addition to a Model 40M square-case 12" chart recorder. Circuit disturbances can neither affect the positiveness of the remote measurements nor impair their accuracy, it is said, because the system does not depend on electrical balance but employs the "Chronoflo" duration-of-contact principle (see *Instruments*, Vol. 5, Oct. 1932, page 244). Fig. 1 is a front view of transmitter with cover plates removed; Fig. 2 is a circuit diagram of the entire system.

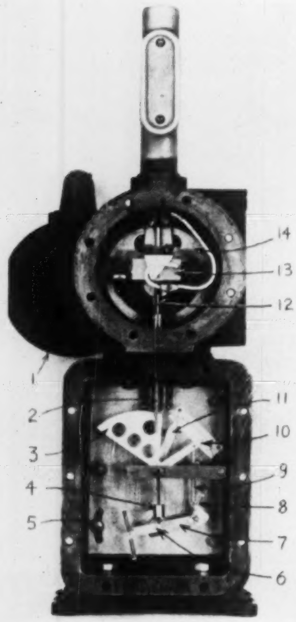


Fig. 1

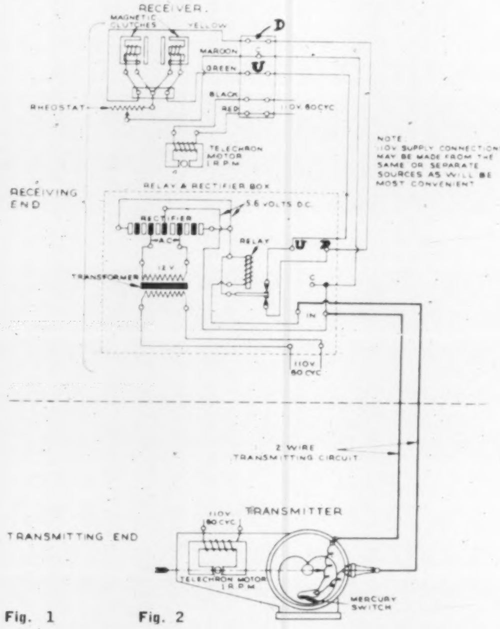


Fig. 2

1. **Motor housing**
2. **Cam position detector**
3. **Positioning cam**
4. **Counterweight**
5. **Zero adjustment**
6. **Measuring element spindle**
7. **Lever arm actuated by measuring element**
8. **Micrometer adjustment**
9. **Connecting link**
10. **Cam shaft arm**
11. **Indicator**
12. **Tripping rod**
13. **Contactor carriage**
14. **Continuously-rotating cam**

Operation: Measuring element (at back of transmitter—not visible in Fig. 1) rotates spindle 6, thereby positioning cam 3 through lever 7, link 9 and lever 10. Cam 14 rotates continuously (usually at 1 r.p.m. and usually by means of a Telechron) and periodically lifts contactor carriage 13, the duration of contact in each cycle being determined by cam 3 through tripping rod 12. Referring now to Fig. 2: When contact is made at transmitter, relay closes "U" circuit; and when contact is broken at transmitter, relay closes "D" circuit. While "U" circuit is closed, a magnetic clutch engages the receiver motor and causes one pointer positioning mechanism to move in up-scale direction. When "U" circuit is open, this "up" mechanism drops back to zero to await next impulse (and pointer remains where it was) but at this same moment the "down" mechanism starts moving. This "down" mechanism, in like manner, having traveled for the time of contact off, also returns to its starting position. Once in every cycle, the pen is thus shifted to a new position (if necessary) by one of the two positive drives.

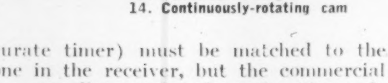
In every individual system, of course, the transmitter Telechron (or other accurate timer) must be matched to the one in the receiver, but the commercial a.c. supplies employed at the two ends need not be of the same frequency. If no a.c. supply is available, a suitable clockwork is fitted into the transmitter or receiver. Although a metallic (2-wire) circuit is preferable, ground return is practicable. Over long distances, public telephone lines may be used through arrangement with A. T. & T. and subsidiaries. Current required to operate a Metameter is 40 m.a. at 6 volts d.c.

Sensitive Relay

Automatic Electric Co.

TWO performance graphs are given out by the manufacturer in lieu of general assertions regarding this new Type 32A 10 Twin Coil Relay. This device is a development of the "high-low" voltage control relay employed in the automatic power-control circuits in Strowger Dial exchanges and is brought out for industrial control applications requiring a micrometer adjusted relay operating within definite narrow limits and responding to a wide variation in applied voltage. By means of the micrometer adjustment of spring tension the relay can be adjusted to operate or release on an exact current value. Fig. 1 shows the various available spring assemblies, in the inoperative condition. The contacts will open and close circuits of 0.5 amp. 110 volt d.c. inductive load; 1 amp. 110 volt d.c. non-inductive load; 1 amp. 110 volt a.c. non-inductive load. The armature is suspended on bronze pivots (one of which is adjustable) to minimize friction and assure accurate motion. It has provision for adjusting residual air gap to secure definite release action, and for adjusting stroke under actual operating conditions. The relay may be fastened to mounting plates or panels in various ways, or may be furnished in various housings, Fig. 2 showing a glass cover and wooden base combination. Thirteen pairs of coils are available, to meet conditions of application, requirements of heat dissipation, etc. Standard coils will safely dissipate 15 watts per pair; special coils will dissipate 20 watts without overheating. Figs. 3 and 4 show the operating characteristics: Fig. 3 plot pull in grams against ampere-turns required to develop that pull for five values of armature stroke: Fig. 4 gives armature load required to restore armature at different settings of residual screw, the values being plotted for maximum degree of magnetization (secured by saturating coil cores for 3 seconds before each observation).

Fig. 1



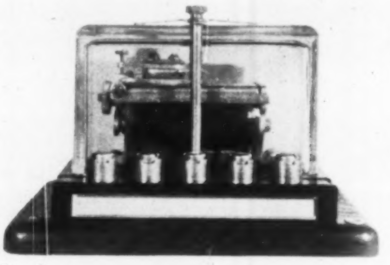
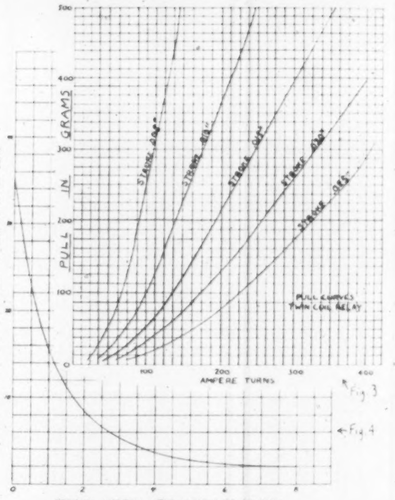


Fig. 2



Small Solenoid Valve

General Electric Co.

AN entirely new solenoid valve for use in standard ¼-in. piping can be used in a wide variety of applications for controlling the flow of water, oil, air, gas, or low-pressure steam at pressures not in excess of 150 lbs./in.^{2} and at temperatures not in excess of 212°F. Its overall height is only $4\frac{3}{16}$ in.

Air-operated Recording and Indicating Controllers

Bailey Meter Co.

COMPLETE elimination of frictional or other drag on measuring elements by control elements has been attained in these instruments, designed for the automatic regulation of flow, pressure, temperature, liquid level and position. The recording pens or indicating pointers are as free to travel over their scales as if there were no connection to a pilot air valve, and this independence is due to the design and construction of the pilot valve itself. Fig. 1 is a schematic diagram of a pressure controller: connecting tube 14 transmits the pressure to coil 3 which actuates both a recording pen (not shown) and lever 13 which is connected to stem 4 of air valve 6 by link 12. Stem 4 carries two equal-size balls 5 so positioned in reference to their respective annular ports that upward and downward forces are balanced at all times. This is shown better in Fig. 2 which is twice actual size. To minimize air leakage, clearance between ball 5 and sleeves 2 or 9 is small (a construction which obviates necessity for stuffing boxes). The negligible flow of air past the close-fitting balls prevents actual metallic contact between balls and sleeves, the air film eliminating friction. Thus, if pin 11 (Fig. 1) were removed, stem 4 would drop freely. The small weights of 4, 11 and 12 are naturally constant and are not a "drag" opposing displacement, so that there never is a variable force, due to control elements, acting on helix 3—provided of course that pilot valve 6 is vertical or nearly so. This may be verified by quickly opening and closing air supply 1 and observing that the recording pen or indicating pointer remains unaffected. It is said that few air-operated controllers can pass such a test, and that any recorder-controller which fails to pass this test produces unreliable records.

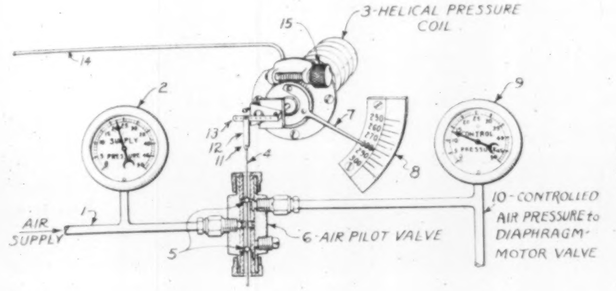


Fig. 1

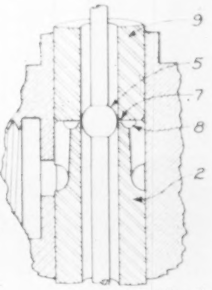


Fig. 2

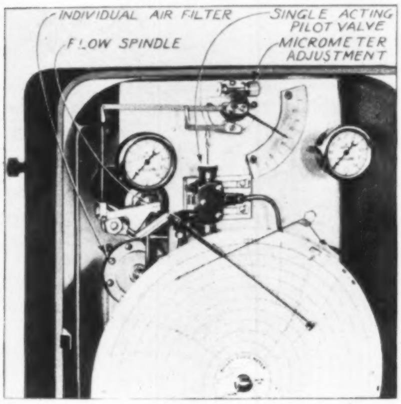


Fig. 3

Another consequence of this novel pilot design is that valve 6 imposes no limits on the travel of the recording pen or indicating pointer. Even when 12 is connected to last hole of 13 in order to make controller respond to extremely small departures from setting point, the entire measuring range of the instrument remains "good," and the records are not "faked" by being kept between mechanical limits.

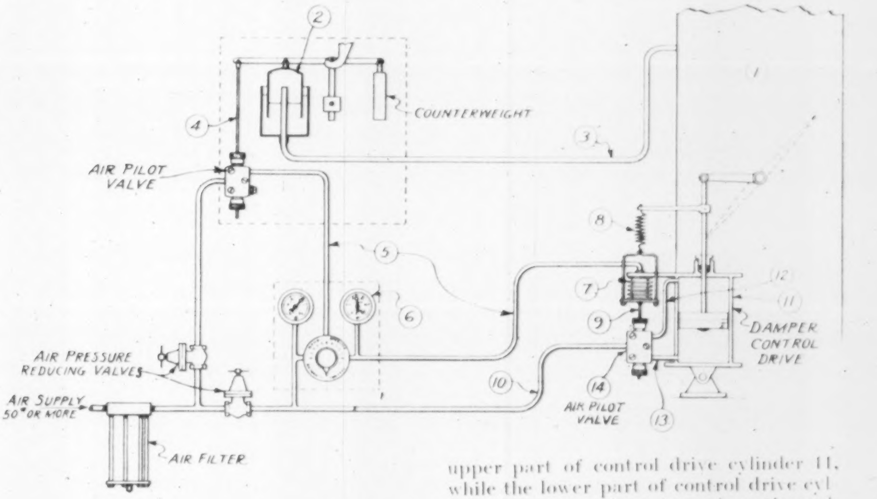
The operation of these new instruments is essentially similar to that of air-operated controllers, the specific function of each controller being to command a diaphragm-motor valve. Gage 2 shows whether the correct pressure is being supplied; gage 9 indicates the air pressure on the diaphragm and hence (within certain limits, generally between 5 and 20 lbs.) the percent opening of the controlled valve. In these instruments the setting is "micrometric" by reason of adjustment 15 which rotates the pressure or temperature helix as a whole. This setting is not "blind" pointer 7 and scale 8 serving to guide the operator.

Fig. 3 shows a flow recorder-controller; the temperature, pressure and liquid level recorder-controllers differ slightly in their interior mechanism. The indicating controllers are made up in round case models.

Positive-drive Air-operated Control Systems

Bailey Meter Co.

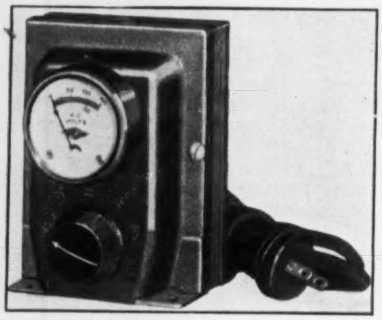
FOR applications requiring that the power device under command of the control instrument be much more powerful than a diaphragm-motor, and at the same time more precise in its small-increment response, the Bailey "Relay Type" Control System has been brought out. Its power device is the new Bailey Pneumatic Control Drive which is a pneumatic cylinder equipped with a novel pilot relay and which utilizes compressed air at the full supply pressure. Its primary element may respond to pressure, temperature or differential pressure and may be a helix, a liquid-sealed bell, a differential manometer, etc. It employs also the new Bailey pilot air valve described elsewhere in this issue. The several elements of a typical system are shown in the schematic diagram, the particular system illustrated being a draft or pressure controller, the purpose of which is to maintain a predetermined pressure in duct 1. Should the pressure drop below the set point, this drop is transmitted to the interior of oil sealed bell 2 by pressure line 3. As this bell moves to balance the pressure in duct 1, it lowers pilot valve stem 4 which opens the control pressure line 5 to atmosphere, thereby decreasing the control pressure as indicated on gage 6. This decrease in control pressure destroys the equilibrium between the force exerted by the control pressure in sylphon 7 and the tension of spring 8, with the result that sylphon 7 contracts and raises relay pilot valve stem 9, admitting air at full supply pressure from line 10 through line 12 to the upper part of control drive cylinder 11, while the lower part of control drive cylinder 11 is opened to atmosphere through line 13. This causes the piston to move downward opening the damper in duct 1, and relieving the tension of spring 8, thereby restoring the balance between the spring tension and the force exerted by the loading pressure in sylphon 7. When this balance is restored, relay pilot valve 14 returns to its neutral position, thereby closing the cylinder of the control drive to both supply pressure and atmosphere.



Voltage Regulator

The Acme Electric & Mfg. Co.

FOR electrical appliances such as radios or refrigerators the "Variable-Voltage Adjustor" permits adjustment of the primary line voltage from either below or above normal to the proper operating voltage. It is similar in construction and appearance to an ordinary step-down transformer, with a series of taps in the case, a manually operated dial, and an instrument to indicate the secondary voltage. It is said to be "ideally suited for service shop use," as it affords a means of testing electrical products under low-voltage and over-voltage conditions, simplifying low-voltage and over-voltage conditions, simplifying the location of some performance troubles.



Audible Fire Alarm

The Gamewell Co.

ENTIRELY self-contained in a Bakelite body, the "Vitalarm Signal" fits any ordinary light socket (115 volt 60 cycle a.c.) and sounds an audible signal when ambient temperature (1) *rises* at a more rapid rate than 15 or 20° F. per minute, or (2) *exceeds* 150° F. The rate-of-rise element is an air-expansion contactor with small leak; the 150° contactor is bimetallic. A small neon lamp at the bottom indicates that current is on and hence that signal is operative (a burned-out lamp, however, will not render device inoperative). "Extension howlers" may be connected to occupied quarters from garages, oil houses and other unwatched fire spots. Frequent testing (a safety requirement) may be made by non-technical persons.

Circular Slide-rule

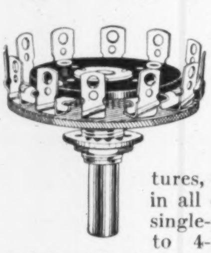
Tavella Sales Co.

AN improved process of etching black lines on nickel silver has made possible the development of this indestructible "Tasco" pocket slide rule which will, it is said, retain its accuracy indefinitely. Diameter is 2.75″; length of multiplication-division scale, 6.3″ as against the 5″ "A" scale of a 10″ regular slide-rule. One side has five scales: log, C, D, Cl or C inverted and K; the other side has sines and tangents, and A and D for squares and square roots. Complete directions are given in the "Tasco Manual" furnished with each scale. It is said that this rule can be dropped, trampled on, or immersed in liquid, without impairing original accuracy.

Wave Band Switch

H. H. Eby Mfg. Co.

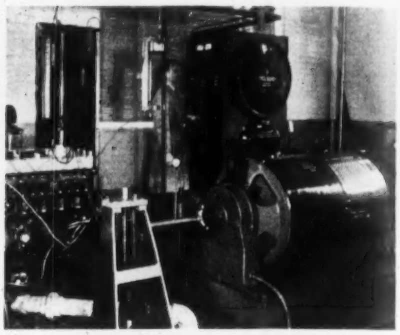
DEFINITE indexing is one of the characteristics of this new switch; others listed by maker being compact design, low capacity, sturdy construction, single-hole mounting, silver-plated contacts and low contact resistance, special solder lug features, etc. It is furnished in all combinations, from single-pole single-throw to 4-pole double-throw and is claimed to be able to withstand rigid life tests.



Improved Dynamometer

Westinghouse Elec. & Mfg. Co.

INASMUCH as the generator cradle of a dynamometer swings but a few degrees when the scale is loaded or unloaded, accuracy of measurement depends on elimination of friction in this movement. Even with ball bearings the static friction is greater than the running friction, and the few balls at the bottom of the bearing carry nearly all the load and tend to fatigue. It is reported that both difficulties were solved by rotating the bearing even when the cradle and the pedestal supports stand still. A new and interesting bearing is required: the inner race mounts solidly on the hub of the generator cradle and around this is a row of balls. Outside of this is an intermediate race with still another row of balls between it and the outer race held by the pedestal—like two ball bearings in series.



With both inner and outer races stationary, the intermediate race is rotated through gears by a small motor. All of the balls are kept in motion so that static friction is eliminated. The bearings at the two ends are rotated in opposite directions, consequently the running friction is balanced out. The result is that the friction error has been reduced to 1/5 of its former value.

In this Section we strive to present ALL the news of devices for measurement, inspection and automatic control, in the form of concise technical descriptions. Most descriptions are written by our own engineering staff; some are prepared by manufacturers and carefully censored. NONE IS PAID FOR, DIRECTLY OR INDIRECTLY.

When writing to manufacturers directly, please mention this Section as your source of information.

Explosion-proof Control

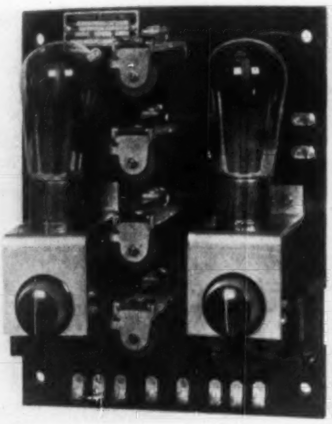
General Electric Co.

ADDITIONS to the line of explosion-proof control equipment include several new devices which have been tested and listed by Underwriters' Laboratories for use in hazardous gas locations. Among these is a "start-stop" push-button station with a cast-iron case and oil-immersed contacts and connections, and two sizes of manual motor-starting switches with air-brake contacts. The larger of these is furnished with either two or three poles for use with single- or 3-phase motors up to 7½ hp. at 440 volts. The smaller size is for use with single-phase motors only in sizes up to ¾ hp. at 110 or 220 volts.

Precision-bore Glass Tubes

Fish-Schurman Corp.

JENA "KPG" tubes are announced in various longitudinal or cross sections with bores accurate to 0.0004″ generally, and to 0.00004″ in special cases. Appearance is that of clear glass tubing—not matted. Various types of Jena glass can be supplied, including G20 which has a low coefficient of expansion and extreme resistance to acids and alkalies. Minimum inside diameter is 0.5 mm.; maximum 50 mm. Precision bores make possible accurate capacity measurements by merely placing a scale alongside the tube, and are necessary in viscosimeters, barometers, manometers, etc.



Pliotron Relay

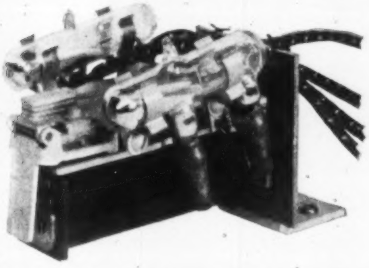
General Electric Co.

IN a double Pliotron relay each of the relaying circuits is employed to respond to the closing of extremely delicate contacts and actuate alarm circuits. In one case, the delicate contact consisted of a simple contact between water and a contact wire. A safety relay is connected in series with the alarm relay. The normal current through the two relays is sufficient to hold the safety relay energized so long as the Pliotron tubes are in operation. In case of tube failure, power failure, or other trouble with the system, this safety relay drops out, thereby energizing a secondary alarm circuit.

Mercury Contact Relay

Automatic Electric Co.

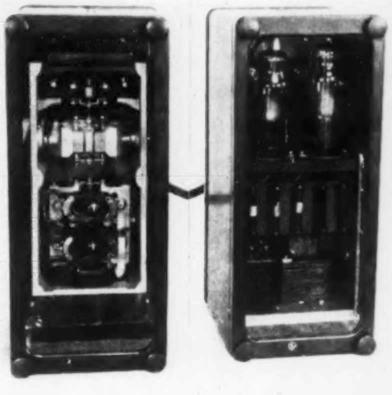
FOR a.c. operation, this new relay will handle comparatively heavy currents, is quick acting and can be equipped with either one or two mercury contacts, either or both of which can be arranged to make or break contact upon the operation of the relay. It is similar to the d.c. mercury contact relay produced by the same company and can be supplied either with an angle bracket and without a cover; or on a Bakelite base with a Bakelite cover, the base being equipped with studs for switchboard mounting. The a.c. relay is designed for operation on 110 volts 60 cycles and has a contact rating of 20 amps. at 120 volts non-inductive load.



"Pilotel" Remote Metering

Westinghouse Elec. & Mfg. Co.

EXTENSIVE interconnected power systems make it frequently necessary to have accurate and reliable indication of volts, amperes, watts, power factor, frequency, etc., at points as remote as 200 miles. It is said that the new Pilotel affords sustained accuracy and unusually fast response. It produces a small flow of direct current proportional to the measured magnitude, which flows through an indicating instrument of standard type, the torque of this instrument being opposed by that of a balancing milliameter. Carried on the same moving system is a pilot coil connected in the grid circuit of an electronic amplifier. The d.c. output of the amplifier flows through the balancing milliameter, the line and the receiving instrument. A change in the torque of the measuring instrument causes the pilot coil to move and this, by means of the amplifier, changes the current flowing in the balancing instrument and external circuit. This change continues until the balancing milliammeter develops an opposing torque exactly equal to that of the measuring instrument. This produces a current which is proportional to the torque, hence proportional to the measured magnitude. Any external condition which changes this current again unbalances the sending instrument, moves the pilot coil and brings about a current from the amplifier which promptly restores the balance. The "sending" end of the Pilotel remote metering equipment, which is the novel part, is illustrated. It consists of the measuring unit (left) and the amplifier (right). The output of the amplifier is controlled by the pilot coil at the top of the measuring unit.



Electronic Control Devices

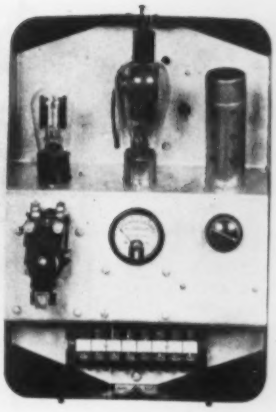
General Electric Co.

Photoelectric Counters

SEVERAL photoelectric relays were designed for counting up to a predetermined and preset number of objects and then closing a control circuit. A photoelectric traffic counter for use on toll bridges is unusual in that although only two light beams cross the roadway, the counter registers vehicles passing in opposite directions separately. If the light is obstructed for more than a few seconds, or in case of a burnout, an alarm circuit warns the tollhouse attendant.

Ultra-high-speed Photoelectric Relay

RESPONDING to light or dark impulses as short as 0.0001 sec., this new relay includes an amplifier tube, a Thyratron tube and a small rectifier tube to supply a source of direct current for operation of the other tubes assembled on a panel and mounted in an enclosing case. A separately mounted phototube is connected to this case by a flexible cable. The amplified phototube impulse changes the voltage on the grid of the Thyratron tube and causes it to conduct. Since the Thyratron tube is supplied with direct current, it continues to conduct even after the impulse has passed. The Thyratron anode circuit has to be reopened by external means before the next operation occurs.



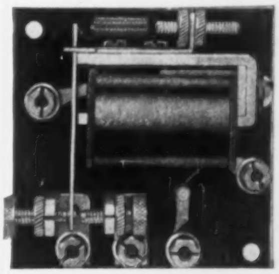
D.-c. Photoelectric Relay

COMPACT and relatively inexpensive, this photoelectric relay, designed to operate from a 115-volt d.c. power supply, is so arranged that the various voltages necessary for the operation of the amplifying system are obtained from a tapped resistor mounted directly on the enclosing case which contains the phototube, radiotron, adjusting potentiometer, and sensitive relay. The resistor is protected by a perforated metal cover. A minimum illumination of 5 foot-candles is required to cause the relay to pick up. The device can be operated from light flashes or interruptions of not less than 1/15 sec. duration with not less than 1/15 sec. between impulses. The power consumption is approximately 35 watts.

Sensitive Relay

Ward Leonard Electric Co.

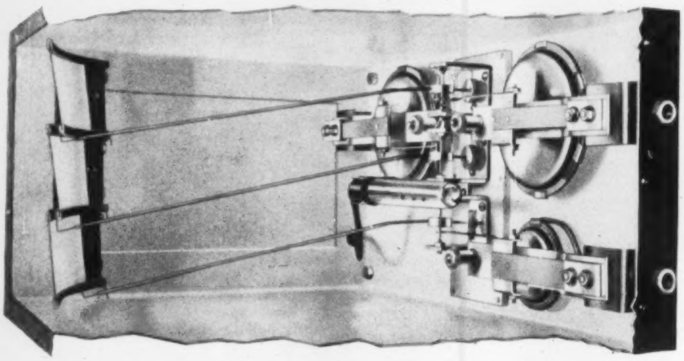
OPERATING on 14 milliwatts, this new relay is said to be suited to photoelectric and similar applications characterized by extremely low current values. The design and construction of the magnetic circuit is said to provide high sensitivity at low induction, good contact torque at pull-up and a crisp constant drop-out that can be adjusted to 85% of the pull-up value. Where smaller gaps between contacts are permissible, it is said that the relay can be adjusted to give positive operation on as low as 4 milliwatts.



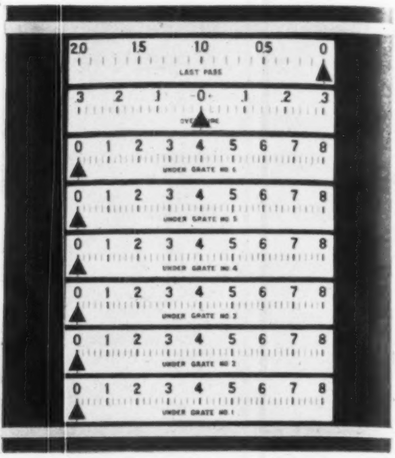
Multi-point Draft and Pressure Indicators

Republic Flow Meters Co.

HORIZONTAL scales permit "stacking" desired number of units as shown in front view. (Vertical-scale instruments also are available.) Standard case width is 18", overall depth 13¾" with only 1" protruding when flush mounted. Draft and pressure elements employ alum-tanned colon leather diaphragms the center areas of which are held by pairs of aluminum disks, each supported in vertical position by a long two-point pivot bearing through which diaphragm motion is transmitted. Thus, diaphragms do not support any parts of mechanisms, and sensitivity is said to be extremely high.



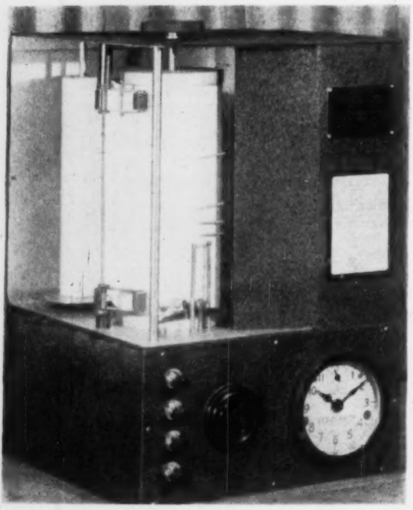
Diaphragms being "slack," pressure-measurement function is performed entirely by calibrated phosphor-bronze loading springs. These are of simple flat form, and heat-treated to assure permanence of calibration. Draft and low-pressure elements with large diaphragm chambers can be stacked without altering uniformity of front appearance, by reason of arrangement whereby they are alternated in right and left of case back to save space. Any element can be removed by loosening one screw and one nut, without interfering with adjacent elements. Cases have side plates easily removable for inspecting or interchanging elements, are dust-proof, and are white-enameled inside to aid illumination of translucent scales.



Performance Recorder for Railway Motor Cars

Commercial Engineering Labs.

DESIGNED to aid in the development and operation of railway motor cars, the new "RMC Recorder" records on a drum chart such data as car speed, engine speed, fuel consumption, tractive effort, time or distance—in almost any desired combination. On the whole it is a specialized model of the "Research" Indicator (*Instruments*, Dec. 1933, page 233). For example, the draw-bar pull recording element is a modification of the "Research" pressure unit. Other elements were developed for the instruments. Among them is a fuel flow remote-metering system whereby a continuous record of fuel rate is made on the same chart with records of speed and pull.



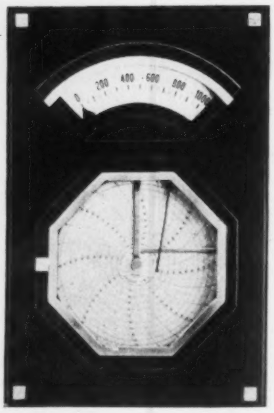
Remote Type Liquid Level and Pressure Gages

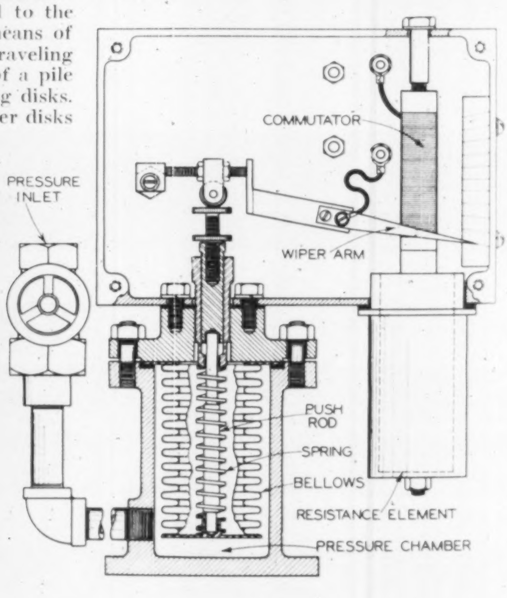
Republic Flow Meters Co.

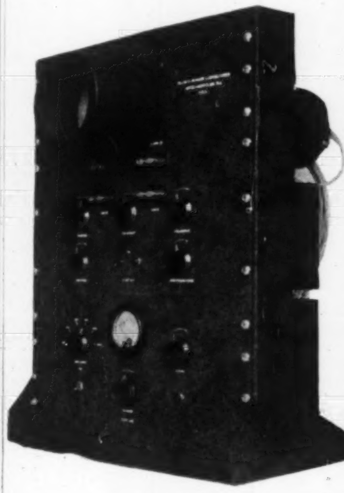
FOR static pressures or liquid heads the transmitter or gage body, shown in sectional front view, consists essentially of (1) pressure chamber sealed at upper end by metal bellows extending within it, (2) pointer mechanism acting as wiper on (3) commutator which varies electrical resistance. Where differential pressure is involved (as in measuring water level in boiler drums and other pressure vessels) the transmitter is a standard Republic flow meter body of the proper differential pressure range and static pressure capacity.

In the new type of transmitter the static pressure is admitted at the bottom of the bellows chamber, to the outside of the bellows, and is opposed by a coiled spring inside the bellows. The motion of the bellows, proportional to the static head, is transmitted by means of a push rod to a wiper arm traveling across a commutator consisting of a pile of alternate copper and insulating disks. The resistances to which the copper disks are connected are wound cumulatively in such a way that the total resistance to each contact is measured during construction. The standard model gage body is used for heads from 10 to 200 ft. of water. For overhead tanks, etc., suppressed-zero models are available. Signal and control models, too, are announced, for commanding automatic pumps, etc., their mercury-switch capacity being 10 amps. at 110 volts. Other models are available for extremely low heads of liquid, for gas pressure remote-reading and -signaling, etc.

The remote instruments are adaptations of the new line of Republic indicators, recorders and combination panels described in *Instruments*, Jan. 1934, page 15.







Laboratory Cathode Ray Oscillograph

An extremely flexible unit, designed for all types of visual or photographic laboratory analysis. Power supply furnished up to 2,500 volts. Linear sweep circuit range from 10-5,000 cycles. Equipped with shielded tube holder and 5-inch cathode ray tube.

Photographic recording possible at speed of spot up to 2,000 inches per second.

This unit can also be supplied with 9 inch cathode ray tube.

In addition to this unit, a number of other cathode ray oscillographs are available, as well as a complete line of cathode ray tubes.

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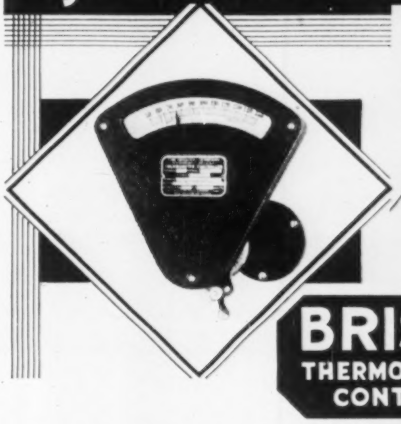

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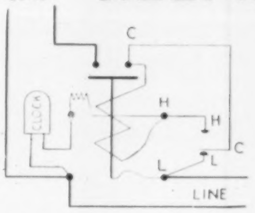

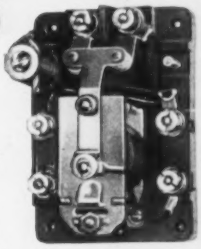

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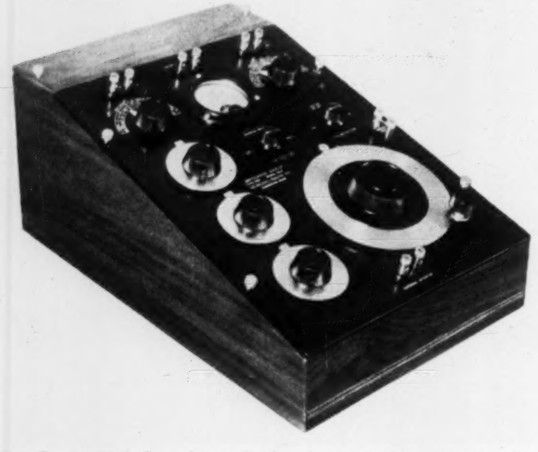

The Type 650-A Impedance Bridge is a complete direct-reading instrument containing everything (except batteries and headphones) necessary to make the following measurements:

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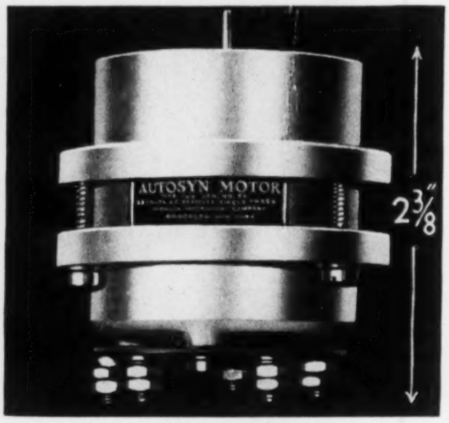

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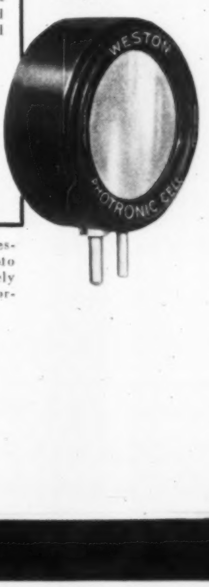

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